The OWL: Software support for a model of argumentation

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The OWL is an "idea cruncher" designed to assist in constructing, analyzing, and comparing debates and arguments. The design philosophy of OWL and the pragmatics of representing argument structures are explained, and applications are presented in three different areas: a 2-year open forum on state revenue issues, an analysis of the cohesiveness of a published argument, and a personalized learning system. The presentation concludes with a prognosis and a discussion of future plans.

Computers have traditionally been thought of as "number crunchers," but in our own personal workspace there is very little number crunching. We are mostly "idea crunchers." Most of our time is spent searching for information, digesting information, and disseminating information, and our purpose is to influence an audience.¹ In this paper I describe a software support system, the OWL, which makes use of the computer as an idea cruncher rather than a number cruncher. The OWL aims to enhance debate on any argumentative subject.

Data overload (or data pollution) is a serious concern in matters of public policy and scientific endeavor. Data are not necessarily information. Words are not always meaningful units of knowledge. Fine speech and beautiful prose are esthetic but may not contain well-constructed arguments. Consider two examples. Henry (1977) concluded his article "Formal Planning in Corporations" with this paragraph:

In conclusion, if formal planning systems are to be effective, problems should be identified as soon as possible in each corporation and remedies used by other firms or new ones designed internally should be employed to solve each problem. If one solution doesn't work, others should be tried. There is no cook-book formula which can be applied in every firm, but the most important ingredient is to find or develop managers who want to do a better job of managing. (p. 45)

Has anything been said? Has anything been said that hasn't been said before? This kind of superficial fluff does not contribute to our knowledge base about formal planning.

As a second example, consider a sentence from *The President's Report 1977-1978* (Bok, 1978), in which the

Harvard Business School was singled out for criticism: "The factors that induce political change are much more inscrutable than the familiar economic variables affecting market behavior" (p. 14). Has anything been said? What is an appropriate response upon reading this? Is there any merit to passive agreement or vigorous disagreement? Does anybody know for sure what is meant by "much more inscrutable," "familiar economic variables," "market behavior"? Most concepts are fuzzy concepts, but when policy is to be based on assertions of this nature, it behooves the participants to take a shot at defining key terms and to provide evidence for otherwise gratuitous assertions. The OWL, described below, says Bok's assertion is neutral. Only evidence and well-defined terms can make it persuasive.

When group decision making is involved, it is necessary to cut through the prose of what is said and written in order to expose the structured argument, if any. Decision makers must be held accountable for what they say or write. In a professional school, a typical learning background designed to train decision makers might include required courses in classical statistics, decision analysis, and operations research, and optional courses in system dynamics, information systems planning, forecasting (or planning), and (remotely) logic. Seldom does any one person take all these courses, and seldom does a corporate executive argue that this is the set of courses that would have helped in handling current decision problems. So how can we speak meaningfully about enhancing debate?

The OWL system is one answer. When a problem is an original, and is qualitative in nature, we need an evolutionary support system to organize and store that information which is considered relevant. The problem itself may initially be vague and poorly understood, so that OWL has to cope with uncertainty, conflicting information, and a changing problem definition. In the next section, the several philosophical underpinnings of OWL are discussed. Then the operational structure of OWL is described. Three different applications of OWL are illustrated in subsequent sections, and the paper concludes with a discussion and prognosis for OWL.

The first-edition OWL program was written by Jason E. Klein (computer science major, Dartmouth College '82) with support from Tuck Associates Funds for the period January-June 1982. The second-edition OWL on the mainframe and the micro-OWL depend heavily on the excellent foundation provided by Jason Klein. The author's mailing address is: Amos Tuck School of Business Administration, Dartmouth College, Hanover, NH 03755.

OWL PHILOSOPHY AND UNDERPINNINGS

The OWL deals with the process of making decisions and aims at reducing information overload. It is at first philosophical and then very definitely pragmatic. The philosophical model is simple. The elements (or units of knowledge) of a debate are *terms* (e.g., noun phrases). For clarity of discourse, *definitions* are needed for key terms. *Assertions* (hunches, hypotheses, conclusions) are connections among terms and are the stuff of a debate. To persuade an audience, *evidence* must be provided to support or refute assertions. And to keep the debate open and honest, all assertions, definitions, and evidence are tagged with a *reference* (i.e., a person or a document).

There are two fundamental tenets:

OWL Tenet Number 1—All assertions are neutral.

OWL Tenet Number 2—It is evidence, not an assertion, that persuades.

The eight underpinnings of this conceptualization of the human decision-making process are as follows:

1. First is the notion of *construct validity*. In 1954 the American Psychological Association published "Technical Recommendations for Psychological Tests and Diagnostic Techniques" and described four types of validity: content, predictive, concurrent, and construct. Concerning the last type, Anastasi (1966) wrote as follows:

Construct validation...[is]...concerned with a more comprehensive and more abstract kind of behavioral description than those provided by other types of validation...[and]...calls for a continuing accumulation of information from a variety of sources. Any data throwing light on the nature of the trait under consideration and the conditions affecting its development and manifestations contribute to the process of construct validation. (p. 307)

At the same time, Anastasi described decision theory as an "attempt to put the decision-making process into mathematical form" (p. 310) and claimed that it was "broader than construct validity in its scope and implications" (p. 310). OWL thinking is rather the reverse. Formal decision-making models are restrictive. In a group decision-making environment, the consensual validation of constructs is what counts. Validation of fuzzy concepts requires an evolutionary knowledge base and some agreed-upon rules of debate.

2. Within the field of statistics, I have asserted (McGee, 1971) that there are three kinds of knowledge: *red knowledge*, *green knowledge*, and *blue knowledge*. Red knowledge is what you know for sure. Green knowledge is what you assume. Blue knowledge is what you get because of what you assume. In the classical hypothesis-testing situation of statistics, red knowledge includes sample data, green knowledge is a set of assumptions (e.g., normality, simple independent random sampling), and blue knowledge is what is derived from these assumptions (e.g., the sampling distribution of the *t* statistic). Generalizing this idea, it is clear that most of what we read and hear is blue. When two TV debaters go at it in an election campaign, both parties are speaking blue. Their blue

statements clash. They are not aiming at reconciliation. If the combatants agreed to make their assumptions (green knowledge) explicit, and if they cared to debate why their assumptions were different, they would both want to refer to "what is known for sure" (red knowledge). Individuals often make decisions (blue) without airing their assumptions (green). However, in group decision-making contexts there is more pressure to consider green knowledge explicitly. In the OWL, red knowledge, green knowledge, and blue knowledge are separated from one another and clearly identified.

3. In the field of decision analysis (e.g., Holloway, 1979), an attempt is made to formalize the decision-making process. The problematical situation is analyzed, simplified, and structured in terms of alternative choices and likely consequences. A serious effort is made to identify the likelihood of occurrence of the various alternatives, and, by imposing a utility function on the decision tree, some "best" decisions (blue) can be identified. Clearly, once a model (green) of the decision process has been defined, an optimal decision (blue) can be defined. In reality, a decision team wants to promote an action which enhances the likelihood of a favorable outcome. In other words, after a decision analysis of a problem, the action taken by a decision team is not merely a decision, but is, rather more importantly, an attempt to control the environment. The OWL acknowledges that the environment surrounding a decision problem is constantly changing, and thus the problem itself is continuously being altered.

4. Zeleny (1972) closed his book on multiple criteria decision making with a chapter entitled "Decision Making is a Very Human Business." He argued that management science has been mostly concerned with the development of "new recipes for structured and well-defined problems," but that this is "much too remote both from the elemental data and from the judgmental integration of the decision maker" (p. 474). He went on to say "decisions must be *efficient*, they must be *effective*, but more and more they should be *explicable*. These three requirements correspond to the interdependence of know-how, know-what, and know-why" (p. 475). Zeleny quoted from Branscomb (1979) as follows:

Computer software will have to be designed with people in mind, not to replace them, but to let people relate to machines in ways that more nearly resemble the ways people relate to one another. All this involves a new personal relationship with the computer, but humans, being intellectually inefficient creatures, may be unprepared for this new interactive role. (p. 473)

The OWL allows for the integration of the decision makers, their various viewpoints, and the relevant (elemental) information.

5. In system dynamics, Forrester (1968) and his colleagues described problematical situations in terms of a hierarchy. First there is a *boundary*, which defines what is to be considered external and internal to the problem. Within the boundary are *feedback loops*, which can be

positive or negative. Feedback loops are made up of *levels* and *rates*. Rates involve four considerations: (1) desired status, (2) current or perceived status, (3) discrepancy between 1 and 2, and (4) action to handle this discrepancy. Levels (such as inventories of goods) can be counted or measured. Rates are what control levels. For example, inventory levels are controlled by an incoming rate and by an outgoing rate. Because rates are the policy variables to a system dynamicist, these are given major attention in the context of decision making. The front end of a system dynamics model involves a *causal loop diagram*, which explicitly defines the feedback loops and all the delay structures in the system. Because the human mind finds it impossible to appreciate the net effect of a variety of feedback loops interacting with one another, it is helpful to use a computer simulation of the problem. The transformation of a causal loop diagram into a simulation program is well understood. What is needed is help in arriving at the causal loop diagram itself. The OWL can make the causal connections between assertions made by any and all participants in a decision task.

6. In the field of logic, syllogisms are invariably deductive. For example,

If A is true, then B is true.

A is true

Therefore B is true.

A more common kind of syllogism in real-world decision making is the following:

If A is true, then B becomes more plausible.

B is true.

Therefore A becomes more plausible.

In other words, concepts in decision making are not usually true or false. They are more plausible or less plausible, and the strength of plausibility is the subject of debate. In a model for plausible reasoning, certain desiderata are important. For example, unambiguity is a requirement. Any statements (or propositions) made by any member of a decision-making team should be unambiguous. An operational definition of an unambiguous statement is a proposition that has a denial. A proposition that does not have a denial is not a proposition. Another desideratum would be consistency. If several decision makers started out with different green knowledge, and were then fed with a steady diet of commonly accepted red knowledge, they should all get closer and closer to a consensual understanding. Finally, a model for plausible reasoning should have a direct correspondence with common sense. In the OWL, the rules for plausible reasoning are made explicit in order to foster a consensus of opinion.

7. In the area of forecasting, the term *forecasting* is sometimes distinguished from *long-range planning*. As Drucker (1959) put it, "We are not dealing with future decisions...but the futurity of present decisions" (p. 239). And Tversky and Kahneman (1974) asserted that "prediction of a remote criterion...is identical to the

evaluation of the information on which the prediction is made" (p. 1126). Even though John Kenneth Galbraith (1977) urged us to "ignore all official economic forecasts...because economic life is a process of constant adjustment to things that never happened before" (p. 97), it is clear that forecasting plays a ubiquitous role in group decision making. OWL's point of view is that forecasts (blue) are made on the basis of models (green) which are more or less related to firm knowledge (red). There is little hope of overpowering one person's green knowledge with another person's green knowledge, except by authoritarian fiat. The OWL helps by providing a forum for debating what is red knowledge, and hence how plausible are the assertions (green-blue) that use this knowledge.

8. Finally, we have the *war room* concept. In IBM's BSP (IBM Business Systems Planning, 1981) approach to the development of information system architecture, a BSP team is identified and works through a highly structured process of top-down planning and bottom-up implementation. The recommended procedure is for the BSP team to have a room which becomes the headquarters for their project, and initially the walls of the room are blank. The procedure for promoting consensus works as follows. Background information for the study is put on the walls in the form of charts and diagrams and members of the BSP team constantly refer to "what's on the wall." As the definition of business processes and data classes proceeds, these too are put on the wall, and any disagreements among the members of the BSP team are reconciled by "modifying what's on the wall." When executives are interviewed by the BSP team, they use the war room and take the executives around the walls as the introduction to the interview. Any disagreements with "what's on the wall" are reconciled by "modifying what's on the wall." In this way, "what's on the wall" becomes the document of consensus agreement. The OWL is a war room.

THE STRUCTURE OF OWL

Initially the OWL knows nothing about a given topic. Information is then solicited (from people and documents), structured (in only five allowable forms), stored (in 5 memory files), retrieved (in interactive mode), and processed (to suggest what needs to be studied). The five allowable forms of communication are designed to promote consistency and rigor in an otherwise unstructured environment, and are designated by the single letters T R A D E. These letters refer to *Terms*, *References*, *Assertions*, *Definitions*, and *Evidence*. They are defined below in a naturally occurring order.

R, Reference²

A reference is either a document citation or a person. The following are examples of references:

R, Governor Sununu of New Hampshire

R, Mathematical Geology, 1981, vol. 13, 479-484

R, President Reagan, personal communication

T, Term³

The elemental units of information are terms, which are usually nouns or noun phrases. For example, *apples* and *oranges* are terms, and so too are the following:

- T, Governor Gallen's budget plan for FY'83
- T, federal taxes paid by individuals
- T, the case method at the Harvard Business School

For any topic, a term is OWL's basic unit of knowledge. All information essential to the topic is contained in terms and in relationships (connections) among terms.

D, Definition⁴

In a communication (debate, argument) it is unlikely that all terms will be defined, but the debate often hinges on the definitions (implicit or explicit) of a few key terms. In order to avoid ambiguity and to promote consensual understanding, the OWL allows for some (or all) terms to be explicitly defined. Definitions in the OWL are free-form, multiline opportunities to clarify a term. Examples are as follows:

- D, economics, the dismal science
- D, linear programming
 - a method for finding the optimum value of an objective function subject to certain linear constraints
- D, Hanover tax rate 1981
 - \$4.64 per \$1,000 of locally assessed valuation

A, Assertion⁵

An assertion is an argument, hunch, conviction, hypothesis, or the like. It is a tool used in argument or debate, but OWL Tenet Number 1 is that all assertions are neutral. A shouted assertion is no better or worse than a whispered assertion. Oratorical skill does not count in OWL. (See Evidence below.) One simple kind of assertion is the IF-THEN assertion, where IF represents green knowledge (assumptions) and THEN represents blue knowledge (what you get because of what you assume). For example,

- A, IF (corporate taxes are reduced) THEN (business is stimulated)
- A, IF (crops are fertilized) THEN (yield is increased)
- A, IF (sales tax in NH) THEN (NH property taxes will not decrease)

Note that the statements inside parentheses are terms, but they are not necessarily noun phrases. In order to make assertions more flexible and more succinct, the OWL system makes use of three qualifiers (symbols) and eight connectors, and after using these the terms above will more nearly be noun phrases.

The Three Qualifiers:

- + means "increases" or "there is an increase in"
- means "decreases" or "there is a decrease in"
- ~ means "not" or "there will not be"

(Note: The absence of a qualifier is permitted.) Using these qualifiers, the assertion

IF (corporate taxes are reduced) THEN (business is stimulated)

may be rewritten as

IF - corporates taxes THEN + business activity

Similarly, the other two assertions above can be rewritten as follows:

- A, IF crops are fertilized THEN + crop yield
- A, IF sales tax in NH THEN ~ - property taxes

In this last case, the combination ~ - is to be read "there will not be a decrease in."

The Eight Connectors:

- < means "less than"
- < = means "less than or equal to"
- > means "greater than"
- > = means "greater than or equal to"
- < > means "not equal to"
- = means "equal to"
- OR means "or" in the usual "logical or" sense
- & means "and" in the usual "logical and" sense

(Note: Depending on the context, these connectors are interpreted with some latitude. For example, the = connector could stand for "is approximately the same as," "are," or "is.")

Here are some further examples of assertions:

- A, apples = red
- A, IF revenues < expenditures THEN deficit
- A, NH per capita property taxes > US per capita property taxes

(Note: It is not necessary that all assertions be IF-THEN statements).

E, Evidence⁶

It is the evidence associated with an assertion that persuades. This is OWL Tenet Number 2. In an open debate, or a group decision-making situation, participants can examine all the evidence and make up their own minds what persuades them. To be persuasive, the evidence should ideally be red knowledge (what is known for sure). A reference may make an assertion but give no evidence. The OWL will store the assertion, but will record that "there is no evidence for this assertion." Examples of assertions and their related evidence are as follows:

- A, IF + state revenues & - state spending THEN balanced state budget
- E, This is what happened between 1975 and 1976 according to budget office report R-13-76
- A, IF + Vitamin C intake THEN - cold symptoms
- E, Linus Pauling said it and he is a Nobel Prize winner

The OWL Software

The original 1982 version of OWL was written in BASIC7 for a mainframe. It is an interactive, command-driven system. The main commands are as follows:

LIST	To print out any of the references, terms, definitions, assertions, or evidence in OWL's memory.
FIND	To search for all terms containing a specified substring and any assertions that use any of these terms.
EVIDENCE	To look for evidence for any assertion in OWL's memory.
INPUT	To input a file of information into OWL's memory.
ADD	To add one item at a time to OWL's memory. The user is identified as the reference of record, and can then add new assertions, add new definitions for a term, or give new evidence for or against an existing assertion.
EDIT	To modify the various parts of OWL's memory. (Note: this command is a restricted option. It requires a password.)
ANALYZE	To analyze any terms by having OWL prepare all the interconnections between all assertions that deal with these terms; to produce what amounts to a causal loop diagram.

Because OWL is designed for maximum flexibility of use, there is no predetermined framework which is applied to all problems. Rather, OWL provides a set of basic tools for information gathering, structuring, and analysis. In the initial stages of preparing an OWL for a given topic, the user would prepare OWL input files (to be read in using the INPUT command), rather than adding (using the ADD command) one item at a time. Thereafter, a typical session with OWL might consist of the following steps:

- Step 1: Sign on to OWL. Identify the topic. Identify yourself.
- Step 2: Retrieve information from OWL's memory either by referring to textual material (use FIND) or by referring to numerically coded information (use LIST).
- Step 3: Use the ADD command to contribute new information. Add evidence for or against existing assertions. Add definitions for existing terms. Add new assertions.
- Step 4: Have OWL examine (use ANALYZE) a particular term or set of terms according to their interrelationships, and the cohesion of the set of assertions that use these terms. This will generate a basic causal loop diagram.
- Step 5: Return to any one of the above four steps and continue.

A new (1985) edition of OWL, written in BASIC8 for a mainframe, is a hierarchical menu-driven system.⁷ Single letters trigger the menu items. The main menu offers

a choice of letters from SHOE IQ (Search, Help, Output, Edit, Input, Quit). Each of these options (except Quit) has its own second-level menu. For example, the Search menu offers a choice of letters from FLEA HQ (Find text, List numbered items, Evidence for an assertion number, Analyze text, Help, Quit). The Edit menu offers a choice of letters from DUCT HQ (Delete, User switch, Change information, Topic switch, Help, Quit). The Input menu allows file input or the addition of one item at a time. The 1985 OWL can use information created by the 1982 OWL. The 1985 OWL was used in Examples 4 and 5 below.

APPLICATION 1: USING THE OWL TO STUDY REVENUE POLICY

During 1982-1983 a five-person task force (set up by The Center for New Hampshire's Future) was charged with reviewing the revenue policy of the New Hampshire government. The task force structured its assignment into three parts: (1) the NHDBS (New Hampshire Data Base System), to contain readily accessible data on revenues and expenditures for the past 10 years at the state, county, town, and school district levels; (2) the NHRR (New Hampshire Revenue Review) OWL, to promote debate on current and new ideas; and (3) the NHPM (New Hampshire Policy Model), a system-dynamics model used to simulate policy choices and effects. In this section I will concentrate on the development of the OWL portion.

In order to get started on the NHRR OWL, the task force drew up a list of key people and asked these people four questions: Which key people do you rely on for information? Which documents have you found helpful? Which questions need to be answered? Which answers do you think you have? Before long, the list of key people and the set of key documents were both well defined. The information obtained from interviews and from the various documents was OWLized (put in OWL syntax) and became the basic knowledge within the OWL. Thereafter, the task force conducted many public meetings in various parts of the state, with live demonstrations of the OWL and open invitations to join in the debate. A telephone number was made available throughout the state so that interested people could call in to the OWL on the Dartmouth College Time-Shared (DCTS) computer and interrogate it on matters of fiscal policy. Those who did not have access to terminals and modems were able to make arrangements with the state library or the legislative budget office, where such equipment was available.

After 18 months of development, the NHRR OWL had a dictionary of some 750 terms and many definitions, assertions, and sets of evidence; the audit trail kept track of who was using the system. Some illustrations of the use of this NHRR OWL are shown in the annotated computer runs (see Appendix). User input is underlined and annotations are preceded by a double colon. Sample Run 1 illustrates the use of the LIST command in the command-driven 1982 OWL. Term 98 refers to the Business Profits

Tax (BPT) and Assertion 20 at the end of this example can be read as follows: "IF there is a land value tax THEN there will be an increase in productive land use."

Sample Run 2 in the Appendix illustrates the use of the FIND command. The NET DEBT IN NH graph hints at why the task force was initiated at that time. Note that the search string INCOME resulted in many terms' being found. There were also many definitions, assertions, and sets of evidence, but some of this information has been excluded in Example 2. New Hampshire has practically no state personal income tax but it is an option to be considered as the revenue situation deteriorates. Thus Term 113, PERSONAL INCOME TAX, was defined by Reference 50 (which happened to be a government-appointed commission of enquiry) in terms of a set of questions asked of all revenue sources (actual or potential). The last portion of Example 2 shows the assertions that include the string INCOME. Assertion 35, for example, states "IF there was a decrease in personal income THEN income tax revenue would decrease by a factor of 1.65 AND sales tax revenues would decrease by .87 times." This is the kind of assertion that is very important to verify (get evidence for) if the legislature is to consider an income tax or a sales tax as a new revenue source. Assertion 47 is the kind of assertion that is hotly debated and needs evidence to be persuasive. It says "IF there is an increase in corporate income taxes THEN there will not be an increase in consumer prices and there will not be a decrease in labor wages and there will be a decrease in shareholder earnings." The NHRR OWL thus serves as a war room, and any individual can participate by using the ADD command to provide new definitions, assertions, or evidence for or against an assertion.

Sample Run 3 in the Appendix shows how the NHRR OWL can be used (say, by a senator preparing a speech) to study a particular subject—in this case, land value tax (LVT). There is no LVT in New Hampshire, but several participants were promoting it as an alternative revenue source, and these individuals contributed a lot of information to the NHRR knowledge base. The user can search for the string LAND VALUE or LVT and can study definitions, assertions, and the evidence for these assertions. If the user has strong feelings about any of this information the OWL will effectively ask: "What is your name and affiliation? What is your definition? What is your assertion? What is your evidence for or against an assertion?"

Note the use of the ANALYZE command toward the end of this run. The OWL does a predecessor and successor analysis for all terms in all the assertions that have been identified. To illustrate successor analysis, suppose OWL is searching for string A and finds an assertion "IF A THEN B." Then it will look for assertions that contain B. If it finds "IF B THEN C" it will follow up C, and so on. Similarly, it would track predecessors of the original string A. If the participants in an OWL development have input a lot of interesting assertions, then the

OWL will be able to create interesting causal loop connections.

APPLICATION 2: USING OWL TO STUDY THE COHESIVENESS OF AN ARGUMENT

Derek Bok's *President's Report 1977-1978* was alluded to earlier. In many circles (including the press), this report was perceived as being overly critical of the Harvard Business School (HBS). The Associates of HBS (executives of some 400 companies that contribute financially and otherwise to the school's research and case-writing programs) stated that they did not share this view, but nevertheless voted to respond to the report by writing their own 52-page report (Board of Directors, Associates of Harvard Business School, 1979). Putting these two reports together, it is of interest to ask which report made the most persuasive arguments. Without underestimating the difficulty of the task, the OWL can be used to handle this question. Sample Run 4 illustrates some of the OWLized terms, definitions, assertions, and evidence that appear in Bok's report.

Many fuzzy concepts are used in this kind of debate and many definitions are less than crystal clear. For example, terms such as *essential nature of professional schools*, *old general manager attributes*, *demand for management skills*, and *adaptation to special nonprofit needs* are at best roughly understood or stereotyped. The term *learn to speak skills* is defined as "learn when to, when not to, and how to speak," which appears to be sound advice but is certainly hard to operationalize. Other definitions serve the audience better. For example, the term *inside pressures* is defined as "unions, women and minorities, less respect for authority and quality of life issues." Assertion 24 argues "IF there is an increase in complexity and an increase in diversification and an increase in inside pressures THEN company objectives are hard to define and corporate planning is increasingly unpredictable." This sounds reasonable, but must be considered neutral (OWL Tenet Number 1) until evidence establishes its plausibility. The evidence for Assertion 17, that "the HBS research record is distinguished," is given by referring to the contributions of various distinguished professors. To an academic audience, this is persuasive.

By persisting in this process of OWLizing the content of two sides of a debate, it is possible to come to a better understanding of the quality of the arguments of both sides. If OWL is used before writing a position paper, it is likely that the arguments will be more cohesive.

APPLICATION 3: USING OWL AS A PERSONAL LEARNING SYSTEM

The OWL can be used as a personalized system of instruction. For example, a student taking a course on a

difficult subject can create an OWL for that topic. Such an OWL can be used for note taking (adding relevant references, terms, definitions, assertions, evidence), for a personal organization of the subject matter (cross-referencing definitions), for updating understanding (adding new definitions, assertions, or evidence as more knowledge is digested), and so on. For illustrative purposes, Sample Run 5 in the Appendix shows how terms and definitions can be recorded in OWL for the study of transfer function (TF) methodology. (See Makridakis, Wheelwright, & McGee, 1983, chap. 10)

DISCUSSION AND PROGNOSIS

OWL is well suited for use in a group decision-making situation. It acts as a war room. Instead of "what's on the wall," it's "what's in the OWL." To keep the debate open and honest, each assertion, definition, and evidence block within OWL is tied to a reference (i.e., a member of the problem-solving group), and at any time, any person can examine the rationale behind another person's argument. They can comment, add to, or reject this rationale by contributing their own information to OWL. Such a process can help the group move toward a common base of red and green knowledge, and, hopefully, to consensual agreement on a solution (blue knowledge).

For a given topic, OWL gets better (more useful) as it is used. Its knowledge base increases, evidence accrues for various assertions, and ideas multiply as more information (assertions) becomes available. In this sense it can help generate ideas. It can make connections among assertions that have been made by different references, regardless of the separation in time and place, and it can generate the rough equivalent of a causal loop diagram. It can point out inconsistencies among assertions, or assertions that are not made that should or could be made.

Because OWL is passively receptive, anything can make its way into memory as long as it conforms to OWL syntax. Multiple definitions of any term are allowed. Any assertion can be made, and multiple sets of evidence can be given either for or against such an assertion. This is a strength of OWL, but can sometimes be a problem if participants are verbose or deliberately wish to obfuscate the issue. To handle this potential in Application 1, the NHRR OWL, the task force acted as managers of the OWL. All additions to OWL's knowledge base were recorded on the AUDIT file, and only members of the task force had the password to edit OWL's memory. All edited memory was also put on the AUDIT file.

As a support system for a debate, OWL is tough minded, in that all assertions are neutral and it is the evidence which persuades. All makers of assertions are asked for evidence for their assertions. No amount of criticism of anything in OWL's memory is of any consequence if the user is unwilling to enter his or her name and enter any definitions, assertions, and/or evidence.

Some of the research questions relating to OWL are as follows. First, can the essence of debate be captured using just TRADE (Terms, References, Assertions,

Definitions, Evidence)? Is it too restrictive or too difficult to put into practice? Second, if different people OWLize the same argument, how similar will their results be? We have encountered ambiguities concerning whether a piece of text is definition or an assertion. Third, we used the OWL as a vehicle for a planning group that met once a month for a year to prepare a short executive seminar. Every meeting involved one or more members' presenting background papers (or their intended contributions to the future seminar), and the rest of the group jotted down terms, definitions, and so on during the presentations. The general opinion was that the principles of OWL made the members better listeners, better readers, and better speakers. This use of OWL needs to be examined under controlled conditions—for example, in teaching children to write, read, or speak better.

What OWL plans are ahead? There are two main wish-list features for the next versions of OWL. First, the software should be available on a microcomputer. This will soon be a reality (see Note 7). However, because OWL software deals primarily with string functions, it will execute more slowly in the micro environment. The menus pop up rapidly, but the search for text can be time consuming, depending on the size of the information base. The mathematical coprocessor chip does not help. One big advantage of using a microcomputer is that red, green, and blue knowledge can be presented in red, green, and blue.

The second desirable feature would be an on-the-screen OWLizer, that is, the ability to extract OWL elements interactively from free text. For example, the screen could be split into a top and bottom window. Free text could be displayed in the top window. A copy of this text could be put in the lower window and could be processed manually (using highlighting or word-processing capabilities) to pick off the terms, definitions, assertions, and evidence contained in the text. This feature has pedagogic potential.

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NOTES

1. In 1980, a Booz, Allen & Hamilton study examined how knowledge workers spend their time. Some 90,000 self-recorded time samples of 299 managers and other professionals were coded and the results were written up in Poppel (1982). The basic results were as follows:

- 46% meetings
25% less productive time
29% thought work:
document creating (13%)
analyzing (8%)
reading (8%)

2. The format for a reference is R, followed by a one-line free-form statement. This can be a very long line, but the idea is to be succinct.

3. The format for a term is T, followed by succinct one-line text, with some restrictions (don't use +, -, ~, >, <, =, &, or the words IF and THEN).

4. The format for a definition is D, followed by the term to be defined, followed by a (multiline) free-form definition. If the definition is brief, it can follow the term on the same line after a comma.

5. The format for an assertion is A, followed by a single line (which can be very long). The OWL software checks it for proper syntax and will parse it into terms, qualifiers, and connectors.

6. The format for evidence is free-form, multiline text. At present, OWL does not parse the text of a piece of evidence. This is to be an option in the next edition of OWL.

7. At the time of writing, the BASIC8 version of OWL is being converted to the true BASIC language for use on either the IBM PC or a 512K Macintosh. Please write to the author for a progress report on this task.

APPENDIX

SAMPLE RUN 1 : Using the LIST command in the NHRR OWL

Note: User entries following a question mark (?) are underlined.
Editorial comments are added (after ::) to clarify the output.

[illegible]

I am the Dartmouth OWL

Which topic do you want (type HELP for instructions)? NHRR

```
What is your NAME and AFFILIATION
? VEM at the OFFICE           :: the user is identified
```

*** COMMAND? LIST REFERENCE 15 :: ask for a specific reference
(R15) "TAXABLE VALUATION PER PERSON IN NH COMMUNITIES: 1970-1980"
OFFICE OF STATE PLANNING (OSP) REPORT

*** COMMAND? LIS REF 15 :: use abbreviated form
(R15) "TAXABLE VALUATION PER PERSON IN NH COMMUNITIES: 1970-1980"
OFFICE OF STATE PLANNING (OSP) REPORT

```

*** COMMAND? LIS TERM 98 :: ask for a specific term
(T98) BPT TAXPAYERS

```

[illegible]

HOW TO EVALUATE A 20% REDUCTION IN "REAL ESTATE TAXES"
IF THIS REDUCTION IS TO BE MET BY

- STATE INCOME TAX, OR
- GENERAL SALES TAX, OR
- SOME OTHER TAX SOURCES?

*** COMMAND? LIS REF 14 :: who was reference 14?
(R14) CARL SHOUP, CONSULTANT, PUBLIC FINANCE; PROF EMERITUS, COLUMBIA U

APPENDIX (Continued)

```
*** COMMAND? LIS ASS 44 :: ask for an assertion
(A44),(R23) IF CONSUMPTION VAT & + TAX ON RETAINED EARNINGS THEN
+ NEUTRALITY
```

*** COMMAND? LIS EVI 44 :: what's the evidence for this?
There is no Evidence for assertion 44.

```
*** COMMAND? STOP
```

OWL is finished with this session.

SAMPLE RUN 2 : Using the FIND command in the NHRR OWL
Note: The following is an edited portion of an actual run.

```
*** COMMAND? FIND NET DEBT          :: search for NET DEBT
```

List of terms found with NET DEBT:
(T255) NET DEBT IN NH :: only one term was found

```

Definitions:                                :: a definition was found
(T255),(R28) NET DEBT IN NH                 :: it came from reference 28

```

NET DEBT IN NH

1937 - 1981

(MILLION \$)

Year	Net Debt (Million \$)
1937	0
1938	0
1939	0
1940	0
1941	0
1942	0
1943	0
1944	0
1945	0
1946	0
1947	0
1948	0
1949	0
1950	0
1951	0
1952	0
1953	0
1954	0
1955	0
1956	0
1957	0
1958	0
1959	0
1960	0
1961	0
1962	0
1963	0
1964	0
1965	0
1966	0
1967	0
1968	0
1969	0
1970	0
1971	0
1972	0
1973	0
1974	0
1975	0
1976	0
1977	0
1978	0
1979	0
1980	0
1981	0

No assertions were found.

*** COMMAND? LIS REF 28 :: who was reference 28?
(R28) COMPTROLLER'S ANNUAL REPORTS

```
*** COMMAND? FIND INCOME          :: search for INCOME
```

List of terms found with INCOME: :: found a lot of terms

(T9) PARKS INCOME
(T31) INCOME TAX YIELD
(T33) INCOME TAXES
(T106) US INDIVIDUAL INCOME TAX 1980
(T108) US CORPORATE INCOME TAX
(T113) PERSONAL INCOME TAX
(T114) RELATIVE PERSONAL INCOME TAX YIELD
(T123) PERSONAL INCOME
(T124) INCOME TAX REVENUE BY 1.65 TIMES
(T126) STATE INCOME TAX
(T128) STATE INCOME TAX DISADVANTAGES
(T154) CORPORATE INCOME TAX
(T166) CORPORATE INCOME TAX SHIFTED TO CONSUMER
(T168) ECONOMIC EFFECT OF CORPORATE INCOME TAX
(T169) CORPORATE INCOME TAX NOT SHIFTED TO CONSUMERS
(T170) VAT SUBSTITUTED FOR CORPORATE INCOME TAX
(T176) PERSONAL INCOME TAX
(T177) LOW INCOME RELIEF
(T178) SUBSTITUTE FOR CORPORATE INCOME TAX
(T211) INCOME TAX
(T231) COMMUTERS INCOME TAX YIELD
(T240) INDIVIDUAL INCOME TAX
(T241) INDIVIDUAL INCOME TAX COMPARISON
(T244) CORPORATE INCOME TAX COMPARISON
(T276) CORPORATE NET INCOME TAX COMPARISON
(T284) SELECTED SOURCES OF INCOME
(T285) FEDERAL INCOME TAX FOR NH 1978
(T292) INCOME TAX BILL

Definitions:
(T31),(R8) INCOME TAX YIELD

FROM "STATE EMPLOYEES ASSOC REPORT 1981" BY CONTE & ENGLAND
THE ESTIMATE IS BASED ON "ABILITY TO PAY" PRINCIPLE. A 5% TAX ON
ALL INCOME ABOVE FEDERALLY ESTABLISHED FAMILY BUDGET (EG, \$29,100
FOR FAMILY OF 4 IN 1981) WOULD YIELD \$120M IN 1981

(T113),(R21) PERSONAL INCOME TAX

SEVEN STATES HAVE NONE (ALASKA, FLA, NEV, SDAK, TEX, WASH, WYOMING)
AND THERE IS VERY LIMITED COVERAGE IN NH, CONN & TENN

(T113), (R50) PERSONAL INCOME TAX	
PREDICTABLE?	YES
TO WHAT EXTENT?	VERY
DECLINING BASE?	
STEADY BASE?	
INCREASING BASE?	10-12% P.A.
COSTLY TO ADMIN?	NO - 1%
COLLECTION PROBS?	NO
SAME RATE SAME USE?	NO
DISCRIMINATORY?	NO
ABILITY TO PAY?	YES
RES MORE THAN NONRES?	INCOME EARNERS
DEDUCTIBLE?	YES

APPENDIX (Continued)

```
* MAIN MENU
*****
      OWL's MEMORY
*****
      S (Search)
      I (Input)
      E (Edit)
      O (Output)
      Q (Quit)

or you can ask for H (Help)
or Q (Quit)

Choose a letter from S H O E or I Q ? S :: choose Search

** The SEARCH MENU is as follows:
*****
      F (Find a text item)      H (Help)
      L (Lookup a numbered item)  Q (Quit)
      E (get Evidence)
      A (Analyze a term)

Input one of the letters in F L E A or H Q ? L T D A E
:: Note - the single letters can be strung together
:: this L T D A E means lookup all terms, definitions,
:: assertions and evidence. Only some will be shown
:: here for the illustration

A list of Terms in the 'HBS' database :: a selection only
*****
(T5) ESSENTIAL NATURE OF PROFESSIONAL SCHOOLS
(T6) MISSION OF PROFESSIONAL SCHOOLS
(T7) BALANCE BETWEEN TEACHING AND RESEARCH
(T8) STUDENT PREPARATION FOR CERTAIN PROFESSIONAL ROLES
(T9) CAREERS IN MANAGEMENT
(T17) EMPHASIS ON RESEARCH
(T24) EMPHASIS ON TEACHING
(T25) RECRUITING OF PROFESSORS
(T35) GENERAL MANAGER FOCUS
(T38) FUNCTIONAL SPECIALIST
(T39) BUSINESS POLICY COURSE
(T40) HBS EXEC PROGRAMS
(T41) QUALITY OF EXEC PROGRAM
(T44) ENRICHED CURRICULUM
(T45) EMPHASIS ON CASES
(T50) LEARN TO SPEAK SKILLS
(T54) HBS RESEARCH RECORD
(T61) CONTRIBUTION OF MIDCAREER FACULTY RECRUITS
(T68) CORPORATION COMPLEXITY TODAY
(T69) CORPORATION COMPLEXITY EARLIER
(T70) INSIDE PRESSURES

A list of Definitions in the 'HBS' database :: a selection only
*****
(T14),(R1) TEACHING
      BOK USES THIS TERM AS SYNONYM FOR EDUCATION
(T23),(R1) SPECIALISTS
      ACCOUNTANTS, PERSONNEL OFFICERS, MARKETING EXPERTS, ETC
(T38),(R1) FUNCTIONAL SPECIALIST
      A SPECIALIST IN PRODUCTION, MARKETING, CONTROL OR FINANCE
(T39),(R1) BUSINESS POLICY COURSE
      TIES FUNCTIONAL SPECIALTIES TOGETHER & EMPHASIZES ROLE OF CEO
(T40),(R1) HBS EXEC PROGRAMS
      FOR PROMISING CORPORATE MANAGERS IN MID CAREER E.G. AMP PROGRAM
(T50),(R1) LEARN TO SPEAK SKILLS
      LEARN WHEN TO, WHEN NOT TO AND HOW TO SPEAK
(T70),(R1) INSIDE PRESSURES
      UNIONS, WOMEN AND MINORITIES, LESS RESPECT FOR AUTHORITY &
      QUALITY OF LIFE ISSUES
(T15),(R1) QUESTION :: Note - a term such as QUESTION
      :: can be defined as many times
      :: as you please
      SHOULD B SCHOOLS BE SCHOOLS OF GENERAL MANAGEMENT?

A List of Assertions in the 'HBS' database :: a selection only
*****
(A2),(R1) ESSENTIAL NATURE OF PROFESSIONAL SCHOOLS & MISSION OF
      PROFESSIONAL SCHOOLS = BALANCE BETWEEN TEACHING AND RESEARCH &
      STUDENT PREPARATION FOR CERTAIN PROFESSIONAL ROLES
(A3),(R1) CAREERS IN MANAGEMENT = + CHALLENGE & + DIVERSITY
(A4),(R1) IF + CHALLENGE & + DIVERSITY THEN + STUDENT INTEREST IN
      B SCHOOLS
(A5),(R1) EDUCATION = TEACHING
(A6),(R1) IF EMPHASIS ON EDUCATION > EMPHASIS ON RESEARCH THEN TRAIN
      ACCOUNTANTS & TRAIN PERSONNEL OFFICERS & TRAIN MARKETING EXPERTS
      & TRAIN OTHER SPECIALISTS
(A8),(R1) IF EMPHASIS ON RESEARCH > EMPHASIS ON TEACHING THEN
      RECRUITING OF PROFESSORS = RECRUITING OF NEW PH.D.'S &
      QUANTITATIVE CURRICULA & - ATTENTION TO DAY TO DAY DECISION
      MAKING
(A16),(R1) LEARN TO SPEAK SKILLS = ESSENTIAL IN CORPORATE DECISION
      MAKING

(A17),(R1) HBS RESEARCH RECORD = DISTINGUISHED
(A24),(R1) IF + COMPLEXITY & + DIVERSIFICATION & + PRESSURES THEN
```

APPENDIX (Continued)

```
COMPANY OBJECTIVES = HARD TO DEFINE & CORPORATE PLANNING = +
UNPREDICTABLE
(A30),(R1) OLD GENERAL MANAGER ATTRIBUTES = EXPERIENCE & INTUITION
(A31),(R1) NEW GENERAL MANAGER ATTRIBUTES = ADVANCED INFORMATION
      SYSTEMS & NEW MANAGEMENT SCIENCE TECHNIQUES

Evidence for Assertions in the 'HBS' database :: one example only
*****
(A17),(R1) HUMAN RELATIONS .. ELTON MAYO & FRITZ ROETHLISBERGER
      DECISION THEORY .. HOWARD RAIFFA
      INDUSTRIAL ECONOMICS .. JOHN LINTNER
      BUSINESS HISTORY .. ALFRED CHANDLER
      INTERNATIONAL STUDIES .. RAY VERNON

*** The LOOKUP MENU : searching by number codes :: still in the
***** :: Lookup menu
      T (Term)      H (Help)
      R (Reference)  Q (Quit)
      A (Assertion)
      D (Definition)
      E (Evidence)

Input one of the letters in T R A D E or H Q ? Q :: quit to get
:: to the Search menu again

** The SEARCH MENU is as follows:
*****
      F (Find a text item)      H (Help)
      L (Lookup a numbered item)  Q (Quit)
      E (get Evidence)
      A (Analyze a term)
      :: now ask OWL to
      :: Analyze EDUCATION

Input one of the letters in F L E A or H Q ? A EDUCATION

List of terms found with EDUCATION:
(T13) EDUCATION
(T16) EMPHASIS ON EDUCATION
(T100) VALUE OF BUSINESS EDUCATION
(T101) VALUE OF LEGAL EDUCATION
(T111) EDUCATION FOR NONPROFIT INST
(T112) B SCHOOL EDUCATION
(T115) SPECIALIZED SCHOOL EDUCATION

Successor Analysis: :: OWL looks for successors

--EDUCATION--
(A5),(R1) EDUCATION = TEACHING
--EMPHASIS ON EDUCATION--
(A6),(R1) IF EMPHASIS ON EDUCATION > EMPHASIS ON RESEARCH THEN TRAIN
      ACCOUNTANTS & TRAIN PERSONNEL OFFICERS & TRAIN MARKETING EXPERTS
      & TRAIN OTHER SPECIALISTS

--VALUE OF BUSINESS EDUCATION--
(A34),(R1) IF + VALUE OF BUSINESS EDUCATION THEN + SENIORS ATTRACTED
      TO B SCHOOLS

--EDUCATION FOR NONPROFIT INST--
(A38),(R1) IF EDUCATION FOR NONPROFIT INST = B SCHOOL EDUCATION THEN
      + MANAGEMENT EFFICIENCY & - ADAPTATION TO SPECIAL NONPROFIT NEEDS
(A39),(R1) IF EDUCATION FOR NONPROFIT INST = SPECIALIZED SCHOOL
      EDUCATION THEN + ADAPTATION TO SPECIAL NONPROFIT NEEDS & -
      MANAGEMENT EFFICIENCY
(A40),(R1) IF EDUCATION FOR NONPROFIT INST = B SCHOOL EDUCATION &
      SPECIALIZED SCHOOL EDUCATION THEN + MANAGEMENT EFFICIENCY & +
      ADAPTATION TO SPECIAL NONPROFIT NEEDS

--B SCHOOL EDUCATION--
(A38),(R1) IF EDUCATION FOR NONPROFIT INST = B SCHOOL EDUCATION THEN
      + MANAGEMENT EFFICIENCY & - ADAPTATION TO SPECIAL NONPROFIT NEEDS
(A40),(R1) IF EDUCATION FOR NONPROFIT INST = B SCHOOL EDUCATION &
      SPECIALIZED SCHOOL EDUCATION THEN + MANAGEMENT EFFICIENCY & +
      ADAPTATION TO SPECIAL NONPROFIT NEEDS

--SPECIALIZED SCHOOL EDUCATION--
(A39),(R1) IF EDUCATION FOR NONPROFIT INST = SPECIALIZED SCHOOL
      EDUCATION THEN + ADAPTATION TO SPECIAL NONPROFIT NEEDS & -
      MANAGEMENT EFFICIENCY

Predecessor Analysis: :: OWL looks for predecessors

--EDUCATION--
(A5),(R1) EDUCATION = TEACHING

--VALUE OF BUSINESS EDUCATION--
(A33),(R1) IF + DEMAND FOR MANAGEMENT SKILLS THEN VALUE OF BUSINESS
      EDUCATION >= VALUE OF LEGAL EDUCATION

--VALUE OF LEGAL EDUCATION--
(A33),(R1) IF + DEMAND FOR MANAGEMENT SKILLS THEN VALUE OF BUSINESS
      EDUCATION >= VALUE OF LEGAL EDUCATION

** The SEARCH MENU is as follows:
*****
      :: still in the Search menu
      :: and we would type Q Q
      :: to quit the run
```