An Expert System for Determining Government Relocation Allowances

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Abstract— *We describe an expert system whose rule base is a formalization of the subset of the federal travel regulations on relocation allowances. Its purpose is to help government employees making a permanent change of station to identify the reimbursable expenses associated with that change of station. We discuss the structure of the regulations, the implications of this structure for the rule base and inference engine, and the components of the user interface.*

1. INTRODUCTION

IN AN EARLIER article, we described an implementation of a prototype of the current system, called RAP (for Relocation Allowance Planner), whose rule base consisted of only a small subset of the applicable regulations and whose user interface lacked some of the important features that have since been added (Roach, Berghel, Meehan, & Green, 1989). The prototype inference engine has also been significantly enhanced [Roach & Berghel, in press (a), in press (b)]. In this article, we provide an overview of the mature version of the system, with special emphasis on the formalization of the regulations and structure of the inferential mechanism necessary to carry out the required deductions.

RAP is intended to be a planning tool for government employees who are to undergo a permanent change of station. Through a consultation with the system the employee can determine what kinds of expenses are identified in the regulations as reimbursable expenses. The employee can plan the move to maximize the reimbursement and minimize the costs that would have to be paid from personal funds. Because the regulations are complex, this approach is much simpler,

less error prone, less time consuming, and less costly than a manual approach. In addition, questions concerning the validity and accuracy of the results can be resolved more easily. The explanation facility generates a report of the reasoning process with explicit justifications of the proposed allowances for each type of expense.

2. RELOCATION ALLOWANCE REGULATIONS

Within carefully defined parameters, the federal government will cover many of the expenses that one of its employees encounters when a transfer from one post of duty to another is required. The conditions, restrictions, and limits pertaining to expense allowances for a change of station are codified in a set of regulations known as the Federal Travel Regulations (U.S. General Services Administration [GSA], 1987). The relocation allowance regulations are divided into 10 sections (USGSA, 1984, 1987). The first section is concerned with the general eligibility conditions for obtaining an allowance. The other nine sections are devoted to the different types of covered expenses. The 10 sections of the manual are:

1. applicability and general rules,
2. travel to the new residence,
3. miscellaneous,
4. travel to seek new residence quarters,
5. occupancy of temporary quarters,
6. buying and selling residences,
7. transportation of household goods,
8. transportation of a mobile home,

9. nontemporary storage of household goods, and
10. transportation of a privately owned vehicle.

The first section is concerned with factors such as employee status, cause of transfer, authorization for transfer, and time and distance restrictions. The conditions in section (1) must be satisfied before *any* allowance can be granted. The remaining nine sections discuss conditions under which an employee is eligible for specific allowances and procedures for calculating those allowances.

Section 2 of the manual is concerned with the expenses for physically moving from one post to another. This includes subsistence and transportation expenses. The parameters of interest are the size of the immediate family, the number of days required to complete the move, and the mileage rate. Miscellaneous expenses and allowances (section 3) cover the costs of a variety of items and activities such as forfeitures of nontransferable medical contracts, registration, and license fees, etc. The amounts allowed depend on whether records are kept, the size of the immediate family, and the amount of the employee's regular weekly pay.

Section 4 governs the expenses for a pretransfer trip to find housing at the new post of duty. Transportation for both the employee and spouse is provided. The per diem for the employee and spouse must be calculated as well as the mileage rate if a personally owned vehicle is used for the trip. The number of trips, the length of the trip, the distance to the new post of duty, and the employee's status must be ascertained. If temporary quarters are to be occupied before a permanent new residence is obtained (section 5) the length of the stay and the number and relationship of other occupants must be known in order to determine an allowance amount. The rates vary depending on the length of occupancy. There are numerous conditions that must be satisfied before eligibility can be established for this allowance.

Section 6 contains the regulations on allowances for the expenses associated with buying and selling homes. Eligibility conditions include having title to old and/ or new residences, living in the old residence before transferring, and providing evidence of transaction expenses. The covered expenses include broker's fees, real estate commissions, advertising and appraisal costs, legal fees, etc. Maximums are based on percentages of actual buying and selling prices. The expenses for transporting household goods (section 7) are based on the method of transportation, weight of the goods, and costs for temporary storage of the goods while in transit (if any). All of these facts must be obtained. Maximum allowances for this category of expenses exist and must not be exceeded.

The costs for transporting a mobile home (section 8) are also reimbursable. Mileage rates (consequently, allowance decisions) depend primarily on the means of transportation: commercial carrier, private means,

some combination of the two, or a government bill of lading. Section 9 governs allowances for storing household goods while at the new residence. Conditions for the allowance are that the transfer is to an isolated station where the goods cannot be stored. Covered costs include packing, crating and transportation to and from the storage warehouse. The final section (section 10) is concerned with the transportation of a privately owned vehicle. There are numerous eligibility conditions that must be satisfied in order to obtain this allowance. The size of the vehicle, who will drive it, why it is being transported, and the cost relative to the length of the transfer are all issues that must be addressed.

3. THE MANUAL SYSTEM

As a large government research institution, the National Center for Toxicological Research employs a number of research and support personnel who fall under the purview of these regulations. Because there are a significant number of personnel changes occurring each year, the center attempts to address the eligible employees' desires for assistance in obtaining a relocation allowance.

The obtainment of all and only those allowances for which an employee is eligible is greatly hindered by the complexity of the travel regulations. Appendix B of the Travel Manual, which is devoted to relocation allowances, is roughly 150 pages of detailed information (USGSA, 1987). The unwary employee, if left to his own devices in interpreting the regulations, is usually overwhelmed by the magnitude of the problem of trying to apply them to his particular situation. Thus, the Center provides someone who is familiar with the regulations to assist employees in determining their relocation allowances.

The process requires that the assistant interrogate the transferee in order to ascertain whether general eligibility conditions are met, which expense categories apply, whether specific restrictions and limitations are met, which rates are to be used, etc. Many questions require yes/no responses; others require that values for various entities be supplied—the number of family members, the distance to be traveled, the weight of various objects, and so forth. This, of course, suggests that the assistant should possess a comprehensive and detailed knowledge of the relocation regulations.

However, the number of employees transferring, and thus requiring some assistance, is not large enough to justify a position devoted just to providing that kind of assistance. As a result, the person who is charged with the responsibility of assisting in allowance determination does so relatively infrequently; consequently, that person does not *specialize* in the relocation regulations. This means that while the expertise at interpreting and applying the regulations is greater than that of the layman, it is still less than what could be provided

by a specialist in the area. Because of the level of demand for assistance with the relocation regulations, it is simply not cost effective to dedicate a person full time to the task. The result is that the employee who is transferring is not getting the level of assistance that could be provided.

4. THE AUTOMATED SYSTEM

The *motivation* for the automated system is that it can provide unerring analyses in a cost effective manner. The user interface is intuitive and simple enough that the layman can use the system to accurately determine his allowances. The *suitability* of the allowance determination process to an expert system style solution is a function of the hierarchical structure and translatability of the regulations and the interactive character of the determination process. The character and organization of the regulations permit a fairly straightforward translation to a standard rule base format. Also, the interactive aspects of the manual system are automated in a very natural way via the expert system's user interface. Figure 1 shows RAP's main menu. On the lower part of the screen the current client is identified, and an indication is given whether a trace, a summary, and/or a set of answers exist for that client. These make up the three categories of information that result from a consultation. The usual options for reviewing and printing the trace are present. However, RAP also provides a tabular summary of allowance amounts and a record of responses given during a consultation. The tabular summary includes a figure for each category of expenses along with a total allowance amount. The information gained as a result of a consultation can be stored and retrieved. This includes the trace, the answers supplied by the user during a consultation, and the allowance summary information.

It is possible to resume a previous consultation using a previously stored set of answers. The system proceeds noninteractively using the retrieved answer set. Should a question arise for which there is no previous answer the system will query the user in the normal manner. This feature is useful for resuming incomplete consul-

FIGURE 2. Editor and sample object value response set.

tations. The previously answered questions need not be repeated.

However, even completed consultations can be resumed. This is usually done with a completed answer set that has been modified. An editor is provided that can be used to modify a previous answer set. Previous answer(s) can be changed, and the system can generate a new trace and allowance summary noninteractively. As a result, whole sessions need not be repeated should one desire to change a previous response. Figure 2 shows the editor screen, in which some of the objects and associated values resulting from a consultation are displayed. Figure 3 shows the screen when a consultation is begun. The top window identifies the section of the manual on which the current query is based. The query itself appears in the next window down. The middle portion of the screen consists of a menu for obtaining the user responses to the query. YES and NO responses are entered by selecting the appropriate menu option (see Figure 4). Numeric responses are entered in the small window at the far left of the menu, as shown in Figure 5. The type of response that is appropriate to a given query is determined before it is displayed. Thus, the highlighting defaults to the correct part of the menu. Finally, the menu provides options for asking why a particular question is asked (the reason is displayed in the bottom window, as in Figure 6) and for aborting the current consultation and returning to the main menu.

FIGURE 1. The main menu.
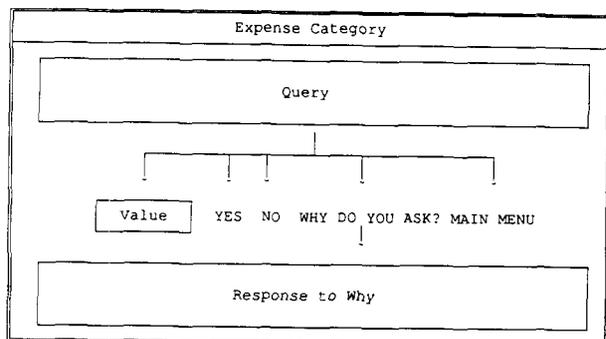
FIGURE 3. Query screen layout.

```
┌─────────────────────────────────────────────────────┐
│   Current Questions Relate to General Eligibility    │
│ ┌─────────────────────────────────────────────────┐ │
│ │ Are you a civilian officer of employee transferring from │
│ │ one official station or agency to another for permanent │
│ │ duty?                                           │ │
│ └─────────────────────────────────────────────────┘ │
│                                                       │
│           ┌────┬──┬─────┬──────────┐                  │
│           │    │  │     │          │                  │
│    ┌──────┐ ┌────┐                                    │
│    │      │ │YES │ NO  WHY DO YOU ASK? MAIN MENU      │
│    └──────┘ └────┘                                    │
│ ┌─────────────────────────────────────────────────┐ │
│ │                                                 │ │
│ └─────────────────────────────────────────────────┘ │
└─────────────────────────────────────────────────────┘
```

FIGURE 4. Sample yes/no valued query.

```
┌─────────────────────────────────────────────────────┐
│   Current Questions Relate to Actual Moving Expenses │
│ ┌─────────────────────────────────────────────────┐ │
│ │ How many family members age 12 or older will relocate │
│ │ with you?                                       │ │
│ └─────────────────────────────────────────────────┘ │
│                                                       │
│           ┌────┬──┬─────┬──────────┐                  │
│    ┌──────┐                                           │
│    │2_    │  YES  NO  WHY DO YOU ASK? MAIN MENU       │
│    └──────┘                                           │
│ ┌─────────────────────────────────────────────────┐ │
│ │                                                 │ │
│ └─────────────────────────────────────────────────┘ │
└─────────────────────────────────────────────────────┘
```

FIGURE 5. Sample numeric valued query.

```
┌─────────────────────────────────────────────────────┐
│   Current Questions Relate to Actual Moving Expenses │
│ ┌─────────────────────────────────────────────────┐ │
│ │ How many members are in your immediate family, including │
│ │ yourself, who will relocate with you?           │ │
│ └─────────────────────────────────────────────────┘ │
│                                                       │
│           ┌────┬──┬─────┬──────────┐                  │
│    ┌──────┐                                           │
│    │      │  YES  NO  WHY DO YOU ASK?  MAIN MENU      │
│    └──────┘                                           │
│ ┌─────────────────────────────────────────────────┐ │
│ │ To determine a value for your mileage rate.     │ │
│ │                      OK                         │ │
│ └─────────────────────────────────────────────────┘ │
└─────────────────────────────────────────────────────┘
```

FIGURE 6. Reason for asking the question.

As a consultation progresses from one category of allowances to the next, the amount of the allowance for the completed category is displayed. At the end of a consultation the trace, summary of allowances, and user responses are saved, and the user is returned to the main menu.

At this point, the results of the consultation can be viewed, printed, modified, etc. The explanation of the reasoning process for the completed consultation is in the form of a 'pretty-printed' trace. Figures 7 and 8 show different portions of a sample trace. The first is a partial justification of the claim that the target client has met the eligibility conditions, and the second partially justifies the amount allocated for a particular type of expense. Finally, the client can view or print a tabular summary of the allowances, as shown in Figure 9.

```
┌─────────────────────────────────────────────────────┐
│            Trace of Reasoning for 7248               │
│ you are eligible for a relocation allowance          │
│    because                                           │
│    you meet the applicability requirements in 2-1.2  │
│       because                                        │
│       you are a civilian officer or employee transferring │
│       from one official station or agency to another for │
│       permanent duty                                 │
│    and                                               │
│    you meet the general provisions in 2-1.3          │
│       because                                        │
│       you have approval for travel from the proper officials │
│       and                                            │
│       you meet the general provisions conditions in 2-1.3a │
│          because                                     │
│          you are transferring in the interest of the │
│          Government and not primarily for you convenience or │
│          at your request                             │
└─────────────────────────────────────────────────────┘
```

FIGURE 7. Portion of explanation for client 7248.

```
┌─────────────────────────────────────────────────────┐
│            Trace of Reasoning for 7248               │
│ your subsistence/transportation allowance = 1970.00  │
│    because                                           │
│    your subsistence/transportation allowance = your  │
│    subsistence allowance per day + the subsistence allowance │
│    for your immediate family per day * the number of days │
│    required to complete the move + your transportation │
│    allowance for relocating                          │
│    and                                               │
│    your subsistence allowance per day = 60.00        │
│       because                                        │
│       your subsistence allowance per day = your per diem │
│       and                                            │
│       your per diem = 60.00                          │
│    and                                               │
│    the subsistence allowance for your immediate family per │
│    day = 120.00                                      │
│       because                                        │
└─────────────────────────────────────────────────────┘
```

FIGURE 8. Portion of explanation for client 7248.

```
┌─────────────────────────────────────────────────────┐
│            Allowance Summary for 7248                │
│ Subsistence/Transportation                $  1970.00 │
│ Miscellaneous Expenses                    $   400.00 │
│ Travel to Seek Residence Quarters         $   800.00 │
│ Temporary Quarters                        $   200.00 │
│ Residence Transactions                    $  1700.00 │
│ Mobile Home                               $     0.00 │
│ Household Goods                           $   800.00 │
│ Nontemporary Storage of Household Goods   $  1300.00 │
│ Personally Owned Vehicle                  $   600.00 │
│                                    TOTAL  $  7770.00 │
└─────────────────────────────────────────────────────┘
```

FIGURE 9. Tabular summary of allowances for client 7248.

5. IMPLEMENTATION

5.1. Translating Regulations to Rules

The prolix regulation*ese* and frequent use of exclusionary clauses are the main impediments to efficient translation of the regulations. For example,

The expenses of travel, transportation, moving and/or storage of household goods, and applicable allowances as provided in these regulations in connection with the transfer or appointment of employees to posts of duty outside the conterminous United States, or between posts located in (i) separate countries, (ii) separate areas of the United States located outside the conterminous United States (e.g., Alaska, Hawaii, the Commonwealth of Puerto Rico), or (iii) any combination of the above, shall not be allowed unless and until the employee selected for such transfer or appointment agrees in writing to remain in the service of the Government for 12

months following the effective date of the transfer or appointment (or for 1 school year for Department of Defense overseas dependents school system teachers as determined under Chapter 25 of title 20 of the United States Code (U.S.C.)), unless separated for reasons beyond his/her control and acceptable to the agency concerned. (USGSA, 1984, p. 2–5)

A careful abridgment of the regulations is a necessary component of the translation process. On the other hand, their rigorous organization increases their translatability. The reason is that the hierarchical relationship of all the parts to the whole is readily discernable. The following excerpt from the table of contents gives some indication of the level of analysis (USGSA, 1984, p. iii):

This organizational scheme is an important plus, since production system rule bases tend to exhibit this same hierarchical structure (Davis & Buchanan, 1985; Minsky, 1985; Nilsson, 1980).

In the initial translation of the regulations, the written manual was taken to be the "expert." That is, the knowledge engineer worked directly from the written regulations in formulating the rule base. The common knowledge acquisition problem of making explicit the reasoning processes of the human expert was not present. Some clarification of the more obscure statements in the regulations was provided by people who had more familiarity with the regulations than the knowledge engineer.

The system has completed one phase of testing and is currently undergoing the second phase. In the first, the person responsible for assisting employees in the manual system verified the rules. In the current testing phase, the system is in actual use, but the results are double-checked.

5.2. The Rule Base

Since we are interested in obtaining an answer to the question "am I eligible for an allowance and, if so, for how much of one?," a goal-oriented, backward-chaining inference engine is employed. Thus, the rule base is organized as a hierarchy of conditions on which the top-level goal is contingent. (There are currently 144 rules in the rule base.)

The structure of the rule base is complicated by the fact that *procedures* for calculating allowances must be

incorporated. Since simple conditional rule bases encode declarative knowledge, some special provision must be made for encoding procedural knowledge (Davis & Buchanan, 1985). [The problem of procedural attachment is a relatively old one in knowledge-based systems (Winograd, 1985)].

A frame-based approach provides one type of solution to the problem (Merritt, 1989; Minsky, 1985). However, we employed a simpler method that facilitates the integration of procedural information into the explanation (trace) of the reasoning process. The procedural information in the regulations can be stated as arithmetic expressions. These expressions undergo a bipartite interpretation by the system. On the one hand, they are interpreted as rules—in much the same way as ordinary conditional rules. In fact, they are intermingled with conditional rules in the rule base. The right-hand side of an expression is treated *as if* it stated conditions for the obtainment of the left-hand side. As a result, the procedural information can be incorporated into the trace in a fashion similar to that used for the declarative information. On the other hand, the expressions are also interpreted as true arithmetic expressions. The values they represent are *calculated*.

We refer to the two rule types as *conditional* and *assignment* rules. The syntax of the conditional rules is a variation on the standard format (Amble, 1987; Bratko, 1986; Merritt, 1989). We define both rule types in terms of a hierarchy of expressions as follows:
Let the vocabulary of an arithmetic expression be
1. a finite set of real-valued variables, $V = \{v_1, v_2, \ldots, v_k\}$,
2. the arithmetic operators '*', '/', '+', '−', and
3. the punctuation symbols '(' and ')'.

We define arithmetic expressions inductively as follows:
1. Real-valued variables and real numbers are arithmetic expressions.
2. If A and B are arithmetic expressions, then so are $(A*B)$, (A/B), $(A + B)$, and $(A - B)$.

If we let the vocabulary of a relational expression be
1. a finite set of real-valued variables, $V = \{v_1, v_2, \ldots, v_k\}$, and
2. the set of relational operators, $O = \{=, <, >, \leq, \geq\}$,
then a relational expression is an expression of the form $v_i \, o \, v_j$ or $v_i \, o \, \mu$, where $1 \leq i, j \leq k$, $v_i, v_j \in V$, $o \in O$, and μ is a real number.

The vocabulary of a sentence evaluation consists of
1. a finite set of sentence variables, $S = \{s_1, s_2, \ldots, s_k\}$,
2. the identity operator '=', and
3. the set of sentence values, $E = \{yes, no\}$.
The resulting sentence evaluations are expressions of the form $s_i = e$, $1 \leq i \leq k$, where $e \in E$.

Let the vocabulary of a logical expression be

1. the vocabularies of relational expressions and sentence evaluations,
2. the set of logical operators, O = {and, or}, and
3. the punctuation symbols '(' and ')'.

A logical expression is defined inductively as follows

1. Relational expressions and sentence evaluations are logical expressions.
2. If A and B are logical expressions, then so are (A and B) and (A or B).

We can now define assignment and conditional rules. The vocabulary of an assignment rule is composed of

1. the vocabulary of arithmetic expressions,
2. the assignment operator '= =',
3. a finite set of sentence variables, S = {$s_1, s_2, \ldots, s_k$}, and
4. the set of sentence values, E = {yes, no}.

There are two forms of the **assignment rule.**

1. If A is a real-valued variable and B is an arithmetic expression, then A = = B is an assignment rule.
2. Any expression of the form s_i = = e, $1 \le i \le k$, where e ∈ E is an assignment rule.

By letting the vocabulary of a conditional rule be

1. the vocabularies of logical expressions and assignment rules plus
2. the conditional operator "if then,"

we can define a **conditional rule** as follows: If A is a logical expression and B is an assignment rule, then if A then B is a conditional rule.

The following rules are instances of the rule schemata. The first rule (a conditional rule) is a translation of the excerpt quoted in the previous section. The second is a typical assignment rule.

5.3 The Inference Engine

The inference engine is written in Prolog and is modeled after the backward-chaining engines described in (Amble, 1987; Bratko, 1986; Merritt, 1989). An in-depth description of the engine can be found in [Roach & Berghel, in press (b)]. It is a meta-level engine, with respect to the intrinsic Prolog engine, for capturing a trace of the reasoning process. According to the van Harmelen classification of expert system architectures (Harmelen, 1989), it is a bilingual meta-level inference system. A model-theoretic analysis of the multilevel relationships between the components of the system is given in [Roach & Berghel, in press (a)].

The standard "why" and "how" traces are constructed as the chaining proceeds through the rule base (Amble, 1987; Bratko, 1986; Merritt, 1989). Since a completely connected rule base forms an and/or graph (Nilsson, 1980), these traces are best viewed as representations of nodes and arcs composing traversals of this graph. The "why" trace is implemented as a list of all the satisfied goals on a path from the root node to the current goal. The satisfaction of the succession of goals on the path becomes the "reason" for pursuing the current goal. The "how" trace is implemented as a tree structure which includes all paths leading to satisfied goals. The satisfaction of the root goal is "explained" in terms of the satisfaction of all goals on which the root goal is contingent.

A conditional rule becomes part of the solution tree when its consequent unifies with the current goal and its antecedent condition(s) are satisfied. The following Prolog clause illustrates the chaining of a conditional rule into the solution space.

```
if
    (('$you$ will $sign a 12 month service agreement$ = yes
or
    ($you$ are $a Department of Defense overseas dependents school system
    teacher as determined under Chapter 25 of title 20 of the United States
    Code$ = yes and
    $you$ will $sign a service agreement for 1 school year$ = yes))
or
    ($you$ are $separated for reasons beyond your control$ = yes and
      $you$ will $transfer with approval of the concerned agency$ = yes))
then
    $you$ meet $the service agreement requirements in 2-1.5a(1) (a-b)$ == yes.
$your subsistence/transportation allowance$ ==
    ((($your subsistence allowance per day$ +
    $the subsistence allowance for your immediate family per day$) *
    $the number of days required to complete the move$) +
    $your transportation allowance for relocating$).
```

```
pursue(Goal=yes, Why, t(t(t(Goal,yes),TruthValue),Reason)) :-
[! recorded(cond_rule(if Conditions then Goal=yes),_) !],
pursue(Conditions,[Goal=yes|Why],Reason),
truth_value(Reason,TruthValue).
```

The goal `truth_value` extracts the truth value from `Reason`, which is instantiated during the recursive attempt to satisfy the rule's condition(s).

In the case of assignment rules, the backward-chaining engine matches the current goal with the left operand of the rule—treating it as it would the consequent of a conditional rule. The right operands are treated as if they were conditions for the satisfaction of the left operand. During the attempted "satisfaction" of these operands, values are associated with each of them. Attempts are made to match each of the right operands with other rules (conditional or assignment). Once the assignment rule has become a part of the proof tree, the right-hand side is treated as an arithmetic expression, that is, it is evaluated. The inference engine clause simply passes the expression on to the appropriate arithmetic routines. The following clause illustrates these points.

the appropriate query is constructed directly from the statement portion of the query. The statement is simply converted from declarative to interrogative form. With other types of relations, the corresponding query is included in the rule base.

Since the Prolog compiler used (Arity Corp., 1988) permits Prolog and C to be integrated, and since C is better suited for handling the user interface, the procedural language C is used for most of the interface routines. C is used for its speed and because sophisticated screen interface libraries are readily available—resulting in a substantial reduction in development time and cost and a substantial increase in the quality of the user interface. For a detailed discussion of the relationship between Prolog and C in the system see (Roach & Berghel, 1990).

```
pursue (Goal, Why, t(t(t(Goal, Value), true), Reason)) :-
    recorded(assign_rule(Goal == Expression),_),
    pursue(Expression,[Goal|Why],R),
    evaluate(Expression,Value),
    Reason = ((t(t(t(Goal,Expression),true),'in rule base') and R),
    recordz(wasderived(Goal,Value),_).
```

The arithmetic expression instantiated to `Expression` is treated as a set of conditions in the recursive call to `pursue`. The 'how' trace for those 'conditions' is returned in `R`. It is treated as an arithmetic expression by `evaluate`. The value that the expression evaluates to is returned in `Value`. The explanation for `Goal` evaluating to `Value` is that a rule of the form `Goal = Expression` exists in the rule base and `R`. The content of `R` is not explicit in this clause, but it consists of explanations of the values associated with each of the operands of the arithmetic expression `Expression`.

5.4. The User Interface

The user interface provides access to a number of useful features and parcels of information. Three forms of explanation are available: a "why" trace, a "how" trace, and a summary of allowance amounts. In addition, the user can access information provided in previous consultations and modify it.

The user interface employs a rudimentary level of natural language analysis in the formation of some queries. When the user must decide the truth value of a relation with statements and responses as operands,

6. EXTENSIBILITY

A couple of extensions to RAP have been proposed. First, if the number of employees using the system becomes substantial, and there is a need for long-term storage of the results of their consultations, then a more sophisticated file management scheme should be employed. The current system uses the operating system's file management facilities, so it does not maintain a single autonomous database. Second, some type of forms generator would be a natural addendum to the system. There are numerous forms that must be filled out by the employee during the determination process. Some of the paperwork required of the employee could be eliminated by letting the system generate the completed forms—using the information available at the end of a consultation.

7. CONCLUSION

We have discussed the automation of the process of determining relocation allowances. We have seen that an expert system approach is a viable one. The representation of the federal regulations in an expert sys-

tem rule base has been described. The procedural information relating to the determination of actual allowance amounts has been encoded in a manner that maximizes the scope of the explanations supplied to the user. We have discussed the system's features for examining the information available at the end of a consultation. Finally, facilities have been discussed which make it possible to store, modify, retrieve, and resume previous consultations.

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