Expert System for Selection of Network-Based Transportation Planning Software Packages

K. NABIL A. SAFWAT AND KHALED EL-ARABY

The rapid proliferation of microcomputer software packages for network-based transportation planning, with different capabilities and limitations, makes it difficult to evaluate and select a package to satisfy the needs and constraints of a particular agency or transportation planner. The software selection process is complex because it involves a multi-objective decision-making process with ill-defined tradeoffs between the objectives as well as the capabilities and limitations of alternative packages. An expert system is described to assist practicing transportation planners and engineers in selecting microcomputer packages for network-based transportation planning to satisfy their agencies' needs and constraints. The Network-Based Transportation Planning Software Selection Advisor (NETSSA) is implemented in LISP on a VAX computer. NETSSA is highly interactive and user friendly. Its current knowledge base includes nine software packages; however, it can easily be expanded by its developers to include additional software packages and/or heuristics. The advice provided by NETSSA is supported with full explanation and reasoning. The user can accept it in whole or in part. NETSSA allows the user to change the relative weights placed on the different aspects and options, assign new weights, and declare specific requirements as being absolutely critical to the user. These flexibilities enable the user to use NETSSA interactively until he or she arrives at a recommendation that would optimally satisfy his or her agency's "realistic" needs and constraints.

Almost all transportation studies involve systematic analysis processes that include the forecasting of traffic flow patterns on several elements of transportation systems (*1*). Microcomputer technology is developing very rapidly and is becoming increasingly available to more transportation planners and engineers. Consequently, several microcomputer software packages have been developed recently to facilitate network-based traffic forecasting on transportation networks (*2*). Representative packages include TRANPLAN/NEDS, MicroTRIPS, EMME/2, TMODEL2, MINUTP, TRANSPRO, MOTORS, JHK SYSTEM II, CARS, etc.

Although these packages predict traffic flow patterns on transportation networks, their capabilities and limitations differ in several aspects such as maximum allowable network size (i.e., number of zones, nodes, and links), hardware requirements, trip generation capabilities, trip distribution options, modal split approaches, traffic assignment techniques, output reporting options and formats, interactive graphic facilities, prices, maintenance costs, technical support, ease of use, compatability with existing computational facilities, etc. Furthermore, each package is constantly being enhanced over time to increase its capabilities and reduce its limitations.

The selection of the software package that best suits the needs and constraints of a particular transportation agency is certainly a challenge that all transportation planning agencies face. The evaluation and selection process is a complex, time-consuming, and costly one. It involves multi-objective decision making with ill-defined tradeoffs between the objectives of that agency, as well as between the capabilities and limitations of alternative packages. Furthermore, existing packages are constantly being enhanced and therefore, by the time the decision is made, it may very well be already out of date. The Texas State Department of Highways and Public Transportation (SDHPT) is using the "Texas Travel Demand Forecasting Package," installed on the mainframe computer at the Texas SDHPT, and has recently completed a two-year study for the evaluation and selection of a microcomputer software package to be used in different urban areas within the state and to be linked with the Texas Package (*3*). The study involved a detailed comparison of several microcomputer network-based transportation planning packages. The Tri-County Regional Planning Commission, Lansing, Mich., conducted a similar thorough investigation for Michigan Department of Transportation (*4*). The study involved evaluation of 11 network-based microcomputer packages and even included actual site demonstration by several venders. The State of Florida addresses the problem of traffic forecasting in its urban areas through a standardized model structure that can perform a variety of forecasting functions—the Florida Standard Urban Transportation Model Structure (FSUTMS), developed over the last ten years by the Bureau of Multimodal Systems Planning, Division of Planning and Programming, Florida Department of Transportation (*5*). The microcomputer version of FSUTMS is based on one of the microcomputer packages indicated above. The first and second National Conferences on Transportation Planning Applications (1987, 1989), which were attended by over 300 participants, most of whom were transportation planners and practitioners from various agencies (federal, state, local, public, private, MPOs, universities, etc.), and the 1st, 2nd, and 3rd International Conferences on Microcomputers in Transportation (1985, 1987, 1989) were indeed rare occasions for professionals to share their experiences with applications of alternative techniques and software packages to their respective problems.

Artificial Intelligence (AI) is a branch of computer science concerned with simulating human intelligence in a computing

Department of Urban and Regional Planning, Texas A&M University, College Station, Tex. 77843-3137.

machine environment, including natural language understanding, vision, learning, robotics, and expert systems. Expert Systems (ES) is another branch that attempts to simulate or reproduce intelligent problem-solving behavior in a computer program. An ES may be defined as an interactive computer program that incorporates judgment, experience, rules of thumb, intuition, and other expertise to provide knowledgeable advice about a variety of tasks (*6*). An ES differs from a conventional computer in several aspects, including representation and use of knowledge, separation between knowledge base (knowledge that defines the specific problem to be solved) and the inference mechanism that uses the knowledge base to solve the problem at hand, the heuristic nature of the problem-solving process, and the orientation toward symbolic rather than numerical processing of information (*7*).

The appropriate problems for using US are those that require expert knowledge for their solution; the reverse is not true. That is, many problems solved by human experts may not be easily solved by ES techniques. Criteria for selecting an appropriate problem for an ES application have been developed (*8,9*) and include:

1. the problem should focus on a narrow specialty area and should not involve a lot of common-sense knowledge;
2. the problem should not be too easy or too difficult to solve by human experts;
3. algorithmic solutions are impractical because of complex physical, social, political, environmental, and/or judgmental aspects of the problem, which generally resist precise description and deterministic analysis;
4. the problem-solving process should be adapted to handle different types of problems and dynamic situations;
5. knowledge transfer from scarce human experts to other humans is too difficult or may take too long;
6. the problem-solving process involves extensive basic and background knowledge that only a few experts can possess; and
7. high performance results are required in a short time while a human expert is not available.

It should be emphasized, however, that ES should be used as a tool to advise human experts, but not to replace them.

Based on the above review of literature and problem definition, ES technology is believed to be most suited to address the problem of transportation planning software selection.

This paper describes an effort to develop an expert system to assist transportation engineers and planners in selecting the microcomputer network-based transportation planning software packages that would most effectively meet their specific needs and constraints. The bulk of this paper will describe the structure and operation of the Network-Based Transportation Planning Software Selection Advisor (NETSSA). The next section gives an overview of NETSSA, including a listing of the software packages to be considered for analysis, the set of evaluation criteria utilized by the expert system, the assignment of default and user-defined relative weights for different options and evaluation criteria, the operation of NETSSA, and its architecture. The following section demonstrates the flexibilities and capabilities of NETSSA through an example application. The final section includes summary and conclusions.

AN OVERVIEW OF NETSSA

Network-Based Transportation Planning Software Packages in NETSSA

The initial phase of the study included a detailed examination of recent studies where network-based transportation planning software packages were reviewed and evaluated. Two studies that tested and compared the software capabilities and features to a great extent were identified:

1. *A Comparison of Microcomputer Packages for Network-Based Highway Planning*, conducted by the Texas Transportation Institute (*3*);
2. *Michigan Microcomputer Traffic Forecasting Model Evaluation*, conducted by the Tri-County Regional Planning Commission (*10*).

The first study performed a detailed evaluation of four packages and the second included 11 packages. In this paper, NETSSA included the nine packages identified below by their names and developers. It should be clear, however, that other existing or newly developed packages can be added very easily, provided of course that their characteristics are known. In NETSSA, new information can only be added by the system developers in order to maintain accuracy of the knowledge base.

Package	*Developer*
TRANPLAN/NEDS	Urban Analysis Group
MicroTRIPS	PRC Voorhees/RVA/MVA Systematica
EMME/2	Centre de Recherche sur les Transports
MINUTP	COMSIS Corporation
MOTORS	M. M. Dillon Ltd.
TRANSPRO	Transware Systems
JHK SYSTEM II	JHK and Associates
CARS	Roger Creighton Associates
TMODEL2	Metro Transportation Group, Inc.

It should be clear that the authors do not endorse any particular software (or company) included in (or to be added to) NETSSA or recommended by the example application in this paper.

Software Evaluation Criteria in NETSSA

Each of the two studies mentioned above used its own set of evaluation criteria. Although there was a great deal of overlap between the criteria used in both studies, it was clear that the Michigan study involved more detailed classification. In this paper, the most significant evaluation criteria, particularly those which were clearly identified in both studies, were classified into ten basic categories; each category included several related characteristics and/or options. The ten categories were also classified into two major groups. The first four categories are basic modeling analysis options:

1. Trip generation (trip generation equations, category rates, and trip generation rate estimation);

2. Trip distribution (fratar, exponential gravity, friction factor gravity, K-factors, and gravity calibration);
3. Modal split (binary logit, diversion curves, and full network transit modeling); and
4. Traffic assignment (all-or-nothing, dial multipath, incremental multipath capacity-restrained, iterative capacity-restrained, iterative multipath capacity-restrained, equilibrium assignment, and turn prohibitors).

The other six categories are supporting analysis options:

5. Network size (maximum allowable number of zones, nodes, and links);
6. Package limits (maximum allowable number of trip purposes and trip generation variables);
7. Package prices;
8. Hardware requirements (IBM-PC or compatible, floppy or hard disk drives, screen displays, dot matrix printer, plotters, and high-resolution color monitor);
9. Report options (unloaded network, selected paths, link loads, turning movements, assignment convergence, VHT/VMT summaries, and ground count comparisons); and
10. Graphics capabilities (highway networks and loads, interactive network editing, highway paths, transit networks and loads, zonal data and matrices, and node volumes and delays).

Assignment of Weights to Software Evaluation Criteria in NETSSA

In order to reflect the relative importance of alternative options within different categories of the evaluation criteria, NETSSA includes default weights assigned to each of the four basic modeling analysis options identified above. This is particularly useful in reflecting the tradeoffs involved in the selection process. For example, in the traffic assignment category, the iterative capacity-restrained assignment option was given a weight of 0.6, while the equilibrium assignment option was given a weight of 0.8. A package that has equilibrium assignment capability but does not have capacity-restrained is therefore evaluated higher compared to another one that does not have equilibrium assignment but has capacity-restrained. In situations where none of the packages satisfies all user-defined modeling needs, NETSSA will recommend as its first selection the package that has the highest overall weight in satisfying as many user-defined modeling options as possible, and the one with the next higher weight as the second selection.

NETSSA will also identify the options that the recommended packages do not satisfy and the requirements for their operation. This is also true in case there are two or more packages which satisfy all user-defined modeling needs. If the user does not agree with NETSSA's default weights or recommendations, he or she can specify his or her own weights for alternative modeling options. In fact, the user can also add his or her own weights to any other supporting analysis options. Furthermore, if there is an absolutely critical criterion that must be satisfied, the user can assign a very high weight to that particular option or constraint. The user-assigned weight will override NETSSA's default weight, and the recommendations will be based on the user's own weight. Of course, multiple critical criteria may be specified simultaneously.

Operation of NETSSA

NETSSA is basically an advisor that mimics a search by a knowledgeable transportation engineer or planner. It incorporates judgment, experience, and other expertise to provide advice about the selection of the software that meets the user needs and constraints. An overview of the five main tasks performed by NETSSA is shown in Figure 1. These steps are:

1. Identification of satisfied and unsatisfied evaluation criteria. NETSSA queries the user to input the software packages to consider in the selection process, his chosen modeling analysis needs (i.e., trip generation, trip distribution, modal split and traffic assignment options), and other supporting analysis needs and constraints (i.e., network size, trip purposes and trip generation variable limits, hardware requirements, budget and graphics options). Then through the incorporation of both the heuristic knowledge present in the system and the user input, the evaluation options that are satisfied, not satisfied and/or may not be satisfied due to insufficient information are identified for each chosen package and shown accordingly to the user.
2. Evaluation of each package. Given the current standing of each software package with respect to the different user-

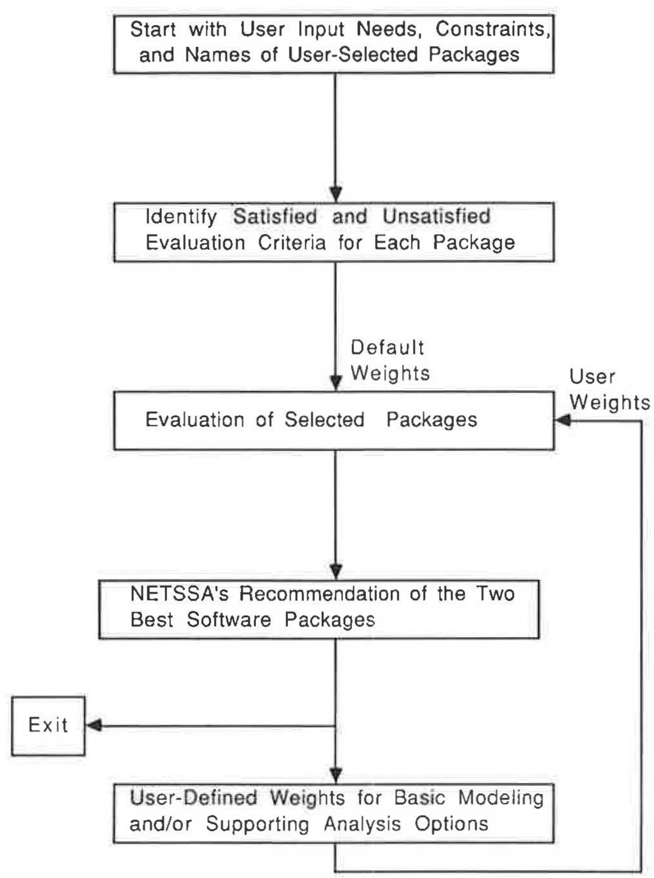

FIGURE 1 Operation of NETSSA.

defined needs and constraints, and given the default weights assigned by the system developers to each modeling analysis option, the overall weight of each package is evaluated.

3. Recommendation of software packages. The software package with the highest "relative merit" or highest overall weight is then recommended to the user. NETSSA identifies the options that the recommended package does not satisfy and the requirements (package limits, minimum memory, etc.) for operating the package. NETSSA also recommends a second-best software package together with its merits and requirements.

4. Modification of weights. NETSSA then allows the user to modify its default weights of the modeling analysis options provided by the system developers. At this point, the user can also assign new weights to other supporting analysis options (e.g., hardware requirements, budget limit, and maximum network size). These flexibilities enable the user to reflect his or her own judgment about the relative importance of all options. The user can even identify some options as absolutely critical requirements that *must* be satisfied in the selected software. The user, however, has to be cautious when specifying his own weights. Assignments of weights to supporting analysis options can jeopardize the effect of the basic modeling analysis options on the selection process.

5. Recommendation based on user-defined weights. After NETSSA receives the user-specified weights, the system searches for the software package that meets all the user critical requirements, if any. If no package satisfies the critical requirements, the user is notified and has the opportunity of either making changes to the critical options and weights or to exit the system. If the user selects to continue, NETSSA repeats Steps 2 and 3 with new user weights from step 4 and recommends the software package with the highest relative merit together with the second-best choice. The system also gives the merits and operating requirements of each recommended package.

Interactive analysis of options and their respective weights may be repeated as many times as the user wishes until he or she reaches an "optimum" solution for his or her "realistic" needs and constraints. An example application described later in this paper will provide more insight into the operational flexibilities and interactive capabilities of NETSSA.

Architecture of NETSSA

One fundamental characteristic of expert systems is that the knowledge used to solve the problem is expressed primarily in symbolic terms. NETSSA is written in LISP language and is implemented on a VAX mainframe computer. LISP was chosen because of its power for representing, storing, and retrieving symbol structures and its flexibility with respect to the problem-solving strategies. Figure 2 shows the architecture of NETSSA. Below is a description of each of its components. A more detailed and general description of components of expert systems may be found elsewhere (*6–9,11*).

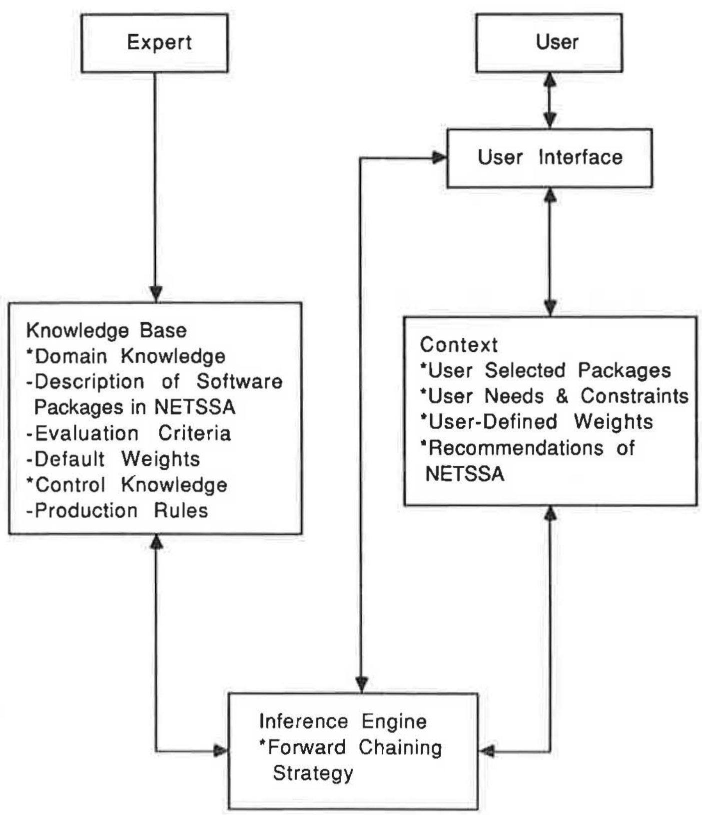

FIGURE 2 Architecture of NETSSA.

Knowledge Base

The knowledge base is the powerhouse of the expert system. It contains all relevant information, facts, causal knowledge of the domain, and heuristics used for problem-solving activities. In NETSSA's knowledge base, the domain and the control knowledge of the problem are included.

The first type of knowledge (i.e., domain knowledge) consists of the features, capabilities, package limits and analysis features for each of the nine software packages. Table 1 shows an example of the domain knowledge on traffic assignment features offered by several packages. Other types of data, such as default weights assigned to basic modeling analysis options, are also present in the domain knowledge. The domain knowledge is represented as object-attribute-value triplets or OAV. In this scheme, object may be a particular software package. Attributes are general characteristics or features of objects (e.g., network size limits, trip distribution features). The final member of the triplet is the value or nature of that attribute (e.g., trip distribution options may include friction factor gravity distribution or fratar distribution). Figure 3 shows an example of an OAV representation.

The second type of knowledge (i.e., the control knowledge) includes all the rules and procedures that determine how the domain data are related and the basis for assigning weights and selecting the softwares. In NETSSA, this knowledge is represented in the form of production IF-THEN rules, in which the satisfaction of one or more premises leads to one or more actions or consequences.

Context

The context is the component of the expert system that contains all data, symbols, true facts, or rules that reflect the current status of the problem. The context in NETSSA will initially contain information about the packages specified by the user to be evaluated and the user's set of needs and constraints. The context would expand as the problem-solving process expands to include, for example, information about the options that are satisfied or not satisfied by each package. It can also include information about the overall weight of each package and the user defined weights.

TABLE 1 TRAFFIC ASSIGNMENT FEATURES OF SOME PACKAGES (*3,10*)

Packages	All-or-Nothing	Dial Multipath	Incremental Multipath	Iterative	Iterative Multipath	Equilibrium
TRANPLAN/NEDS	X	X	No	X	No	X
MicroTRIPS	X	X	X	X	X	X
EMME/2	X	No	No	X	No	X
MINUTP	X	X	X	X	X	X
JHK-System/II	X	X	X	X	X	X
CARS	X	No	No	X	X	No

* X=Feature is available
No=Feature is not available

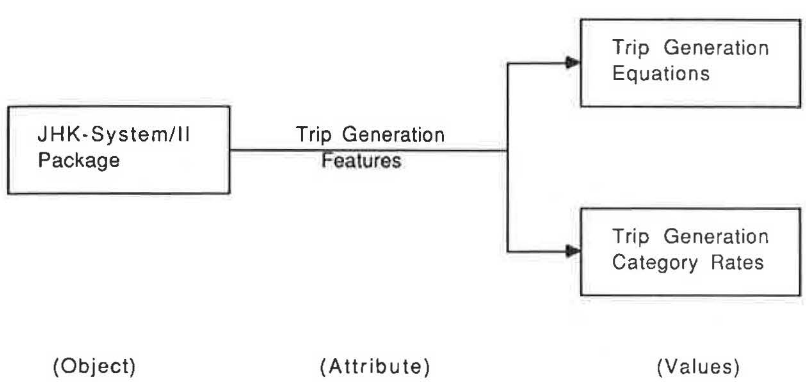

FIGURE 3 Example of object-attribute-value (OAV) representation.

Inference Engine

The inference engine is responsible for the execution of the expert system through manipulation of the knowledge base and context. The inference engine locates and executes an "active" rule (one in which the premise is satisfied) and executes the required action. This is done by detecting changes in the context, comparing the context with the knowledge base, and deciding which action would be most appropriate. The process of selecting active rules is repeated until no rule can be satisfied or until a prediction indicates the end of the session.

In NETSSA, the forward chaining processing strategy is utilized. According to this strategy, the expert system works from an initial state of known facts (user input and domain knowledge) and searches for the best conclusion (i.e., most appropriate software that fits these facts). In Steps 3, 4, and 5 described above, the expert system begins with the recommended package based on the system default weights. It determines whether it is appropriate for the user-defined weights and critical requirements. If it does not support the user requirements, the expert system pursues the validity of other packages in the knowledge base.

User Interface

The user interface allows the user to interact directly and efficiently with the system. It prompts the user to input his facts and data, and provides him with explanation and reasoning for the decision reached. In NETSSA, user inputs include the available packages, evaluation constraints, user weights, etc. NETSSA's outputs include (1) identification of packages that satisfy all user input needs and constraints, if any; (2) the 1st and 2nd recommended software packages; (3) the features satisfied, unsatisfied, and possibly satisfied by each package; (4) the default or user-defined weights based on which the decision was made; and (5) the requirements for operating the recommended packages.

Example Application

In this section, an example application of NETSSA is demonstrated. NETSSA begins by welcoming the user and listing the available software packages in the system. It then prompts the user to select the packages that he would like to include in the selection process (see Figure 4). In this example, the user chooses five software packages to include in the selection process. The chosen packages are: TRANPLAN/NEDS, MicroTRIPS, EMME/2, TRANSPRO, and MINUTP.

The user then specifies his basic modeling and supporting analysis options that fit his specific needs and constraints. In this example, the user identifies the following options:

1. Trip generation equations, trip generation rate estimation;
2. Friction factor gravity distribution, K-factors, gravity self calibration;
3. Binary logit modal split, full network transit modeling;
4. Equilibrium assignment, and turn prohibitors.
5. Max. no. of zones < 1500, max. no. of nodes < 16,000, max. no. of links < 16,000;
6. Max. no. of trip purposes < 15, max. no. of trip generation variables < 26;
7. Budget limit = $3000;
8. IBM-PC or compatible, hard disk drive, screen displays, dot matrix printers;
9. Report VHT/VMT summaries, report turning movements, report links loads and selected paths, report unloaded network; and
10. Interactive network editing.

Once the user inputs his options as defined above, NETSSA evaluates each of the five packages and displays for each package the options which are satisfied, not satisfied and/or may or may not be satisfied for insufficient information. In this example, the information displayed for TRANPLAN/NEDS is shown in Figure 5. Again, similar information is displayed for each of the five packages.

Using the default weights in NETSSA, it recommends two software packages. For each of the recommended packages, NETSSA displays the user-defined options not satisfied by the package, if any, together with the requirements for operating the package. In this example, the NETSSA made the recommendation shown in Figure 6.

At this point the user may elect to exit NETSSA or to continue by specifying his own set of weights for basic modeling options, as well as new weights for other supporting

```
WELCOME TO THE NETWORK-BASED TRANSPORTATION PLANNING SOFTWARE SELECTION ADVISOR

                                * NETSSA *

THIS PROGRAM WILL ASSIST YOU IN CHOOSING THE SOFTWARE PACKAGE THAT
WILL BEST SUIT YOUR NEEDS FOR YOUR TRANSPORTATION NETWORK ANALYSIS PROBLEM
==============================================================================

THE SOFTWARE PACKAGES AVAILABLE ARE :

TRANPLAN/NEDS        MICROTRIPS          EMME/2
MINUTP               MOTORS              TRANSPRO
CARS                 JHK-SYSTEM/II       TMODEL2
```

FIGURE 4 NETSSA's welcoming message.

```
TRANPLAN/NEDS SATISFIES THE FOLLOWING OPTIONS

(MAX. NO. OF ZONES 1500)  (MAX. NO. OF TRIP PURPOSES 15)
(BUDGET LIMIT $ 3000)     (DOT MATRIX PRINTERS)      (SCREEN DISPLAYS)
(HARD DISK)               (IBM-PC OR COMPATIBLE)
(TRIP GENERATION EQUATIONS)
(GRAVITY SELF CALIBRATION)                           (K-FACTORS)
(FRICTION FACTOR GRAVITY DISTRIBUTION)
(FULL NETWORK TRANSIT MODELING)                      (TURN PROHIBITORS)
(EQUILIBRIUM ASSIGNMENT)  (REPORT VHT/VMT SUMMARIES)
(REPORT TURNING MOVEMENTS)                           (REPORT LINK LOADS)
(REPORT SELECTED PATHS)   (REPORT UNLOADED NETWORK)
(INTERACTIVE NETWORK EDITING)


TRANPLAN/NEDS DOES NOT SATISFY THE FOLLOWING OPTIONS

(MAX. NO. OF NODES 16000) (MAX. NO. OF LINKS 16000)
(MAX. NO. OF TRIP GENERATION VARIABLES 26)
(TRIP GENERATION RATE ESTIMATION)                    (BINARY LOGIT MODAL SPLIT)
```

FIGURE 5 Information display for TRANPLAN/NEDS software package.

```
============================================================================

AS A FINAL OUTCOME AND BASED ON OUR OWN DEFAULT WEIGHTS FOR THE BASIC
 MODELING ANALYSIS OPTIONS YOU HAVE SELECTED , IT WOULD BE RECOMMENDED
TO USE :

* 1st. SELECTION :
MINUTP  SOFTWARE PACKAGE

* 2nd. SELECTION:
EMME/2  SOFTWARE PACKAGE


MINUTP  DOES NOT SATISFY THE FOLLOWING USER SELECTED OPTIONS :

(MAX. NO. OF TRIP PURPOSES 15)                       (GRAVITY SELF CALIBRATION)


MINUTP  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 3000)
(MINIMUM MEMORY 256 K RAM)
(FLOPPY DISK OR HARD DISK DRIVES)                    (MAX. NO. OF ZONES 2000)
(MAX. NO. OF NODES 16000) (MAX. NO. OF LINKS 32300)
(MAX. NO. OF TRIP PURPOSES 9)
(MAX. NO. OF TRIP GENERATION VARIABLES 26)


YOUR SECOND CHOICE WOULD BE TO USE :

EMME/2  SOFTWARE PACKAGE


EMME/2  DOES NOT SATISFY THE FOLLOWING OPTIONS :

(MAX. NO. OF ZONES 1500)  (MAX. NO. OF NODES 16000) (BUDGET LIMIT $ 3000)
(TRIP GENERATION RATE ESTIMATION)


EMME/2  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 7500)
(MINIMUM MEMORY 640 K RAM)                           (HARD DISK DRIVE)
(MAX. NO. OF ZONES 800)   (MAX. NO. OF NODES 5000)   (MAX. NO. OF LINKS 16000)
(MAX. NO. OF TRIP PURPOSES 40)
(MAX. NO. OF TRIP GENERATION VARIABLES 100)
============================================================================
```

FIGURE 6 NETSSA's recommendation based on default weights.

options. In this example, the user elected to continue. The weights specified by the user are:

Option	*Weight*
Gravity Self Calibration	0.4
Exponential Gravity Distribution	0.6
Trip Generation Rate Estimation	0.3

Based on these user-defined weights and the default weights not altered by the user, NETSSA's recommendation changed as shown in Figure 7.

As indicated earlier, the user can assign new weights to other supporting analysis options. In this example, the user elected to exercise this option. The user-specified weights are:

Option	*Weight*
Budget Limit	1.0
Max. No. of Trip Purposes 15	0.8
Max. No. of Links 16,000	0.7
Max. No. of Zones 1500	0.9

Based on these user-defined weights and system default weights for the basic modeling analysis options, NETSSA's recommendation again changed as shown in Figure 8.

Finally, the user can specify some critical requirements. In this example the user elected to specify the following critical requirements:

- Budget Limit $3000,
- Max. No. of Zones 1500, and
- Max. No. of Trip Purposes 15.

Again NETSSA offers recommendations and information on the package(s) that satisfies the user critical requirements, as shown in Figure 9. The process could continue as many times as the user wishes until he or she arrives at a recommendation that would "optimally" satisfy his or her needs and constraints.

```
==========================================================================
AS A FINAL OUTCOME AND BASED ON YOUR OWN SET OF WEIGHTS, IT
WOULD BE RECOMMENDED TO USE :

* 1st. SELECTION :
EMME/2  SOFTWARE PACKAGE

* 2nd. SELECTION :
MICROTRIPS  SOFTWARE PACKAGE


 * FIRST SELECTION *

EMME/2  DOES NOT SATISFY THE FOLLOWING OPTIONS :

(MAX. NO. OF ZONES 1500)  (MAX. NO. OF NODES 16000) (BUDGET LIMIT $ 3000)
(TRIP GENERATION RATE ESTIMATION)


EMME/2  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 7500)
(MINIMUM MEMORY 640 K RAM)                           (HARD DISK DRIVE)
(MAX. NO. OF ZONES 800)    (MAX. NO. OF NODES 5000)  (MAX. NO. OF LINKS 16000)
(MAX. NO. OF TRIP PURPOSES 40)
(MAX. NO. OF TRIP GENERATION VARIABLES 100)


 * SECOND SELECTION *

MICROTRIPS  SOFTWARE PACKAGE


MICROTRIPS  DOES NOT SATISFY THE FOLLOWING OPTIONS :

(MAX. NO. OF LINKS 16000) (MAX. NO. OF TRIP PURPOSES 15)
(MAX. NO. OF TRIP GENERATION VARIABLES 26)           (BUDGET LIMIT $ 3000)
(TRIP GENERATION RATE ESTIMATION)


MICROTRIPS  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 4250)
(MINIMUM MEMORY 256 K RAM)
(FLOPPY DISK OR HARD DISK DRIVES)                    (MAX. NO. OF ZONES 2000)
(MAX. NO. OF NODES 40000) (MAX. NO. OF LINKS 14000)
(MAX. NO. OF TRIP PURPOSES 3)
(MAX. NO. OF TRIP GENERATION VARIABLES 18)
==========================================================================
```

FIGURE 7 NETSSA's recommendation based on user-defined weights for basic modeling options.

```
AS A FINAL OUTCOME AND BASED ON YOUR OWN SET OF WEIGHTS, IT
WOULD BE RECOMMENDED TO USE :

* 1st. SELECTION :
MINUTP  SOFTWARE PACKAGE

* 2nd. SELECTION :
TRANPLAN/NEDS  SOFTWARE PACKAGE

 * FIRST SELECTION *

MINUTP  DOES NOT SATISFY THE FOLLOWING OPTIONS :

(MAX. NO. OF TRIP PURPOSES 15)                        (GRAVITY SELF CALIBRATION)


MINUTP  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 3000)
(MINIMUM MEMORY 256 K RAM)
(FLOPPY DISK OR HARD DISK DRIVES)                     (MAX. NO. OF ZONES 2000)
(MAX. NO. OF NODES 16000) (MAX. NO. OF LINKS 32300)
(MAX. NO. OF TRIP PURPOSES 9)
(MAX. NO. OF TRIP GENERATION VARIABLES 26)


 * SECOND SELECTION *

TRANPLAN/NEDS  SOFTWARE PACKAGE


TRANPLAN/NEDS  DOES NOT SATISFY THE FOLLOWING OPTIONS :

(MAX. NO. OF NODES 16000) (MAX. NO. OF LINKS 16000)
(MAX. NO. OF TRIP GENERATION VARIABLES 26)
(TRIP GENERATION RATE ESTIMATION)                     (BINARY LOGIT MODAL SPLIT)


TRANPLAN/NEDS  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 2500)
(RECOMMENDED MEMORY 640 K RAM)                        (HARD DISK DRIVE)
(MAX. NO. OF ZONES 1500)  (MAX. NO. OF NODES 10000) (MAX. NO. OF LINKS 12000)
(MAX. NO. OF TRIP PURPOSES 15)
(MAX. NO. OF TRIP GENERATION VARIABLES 25)
```

FIGURE 8 NETSSA's recommendation based on user-defined weights for supporting analysis options.

```
AS A FINAL OUTCOME AND BASED ON YOUR OWN SET OF WEIGHTS: TRANPLAN/NEDS SOFTWARE
PACKAGE IS THE PACKAGE THAT SATISFIES ALL YOUR -CRITICAL-
REQUIREMENTS

TRANPLAN/NEDS  REQUIRES THE FOLLOWING OPTIONS :

(BUDGET NOT LESS THAN $ 2500)
(RECOMMENDED MEMORY 640 K RAM)                        (HARD DISK DRIVE)
(MAX. NO. OF ZONES 1500)  (MAX. NO. OF NODES 10000) (MAX. NO. OF LINKS 12000)
(MAX. NO. OF TRIP PURPOSES 15)
(MAX. NO. OF TRIP GENERATION VARIABLES 25)


TRANPLAN/NEDS  DOES NOT SATISFY THE FOLLOWING OPTIONS :

(MAX. NO. OF NODES 16000) (MAX. NO. OF LINKS 16000)
(MAX. NO. OF TRIP GENERATION VARIABLES 26)
(TRIP GENERATION RATE ESTIMATION)                     (BINARY LOGIT MODAL SPLIT)
```

FIGURE 9 NETSSA's recommendation based on user-defined critical requirements.

CONCLUSIONS

Several microcomputer software packages have recently been developed to facilitate network-based traffic forecasting on transportation networks. The selection of the software package that best suits the needs and constraints of a particular transportation agency is a complex, time-consuming and costly challenge. Expert system technology was thought to be most appropriate to address this issue of transportation planning software selection.

The Network-based Transportation Planning Software Selection Advisor (NETSSA) developed in this paper was implemented in LISP language on a VAX mainframe computer. NETSSA's current knowledge base includes the nine software packages. Evaluation criteria were identified, and NETSSA's developers further classified these criteria into basic modeling options (for which default weights were assigned) and other supporting analysis options. The default weights in NETSSA were based on the expert opinion of a few transportation systems analysts including the developers. The flexibility of NETSSA was demonstrated by allowing the users to alter these default weights and to assign new weights to any of the supporting analysis options. The user can even declare some options to be absolutely critical requirements that must be satisfied by the selected software.

An example application of NETSSA was described to illustrate the basic features and capabilities of NETSSA. The example application showed that there is no one package that would satisfy all the "desired" user needs and constraints, and the NETSSA's recommendations are quite sensitive to the user-defined needs, constraints, and weights. Therefore, the user would have to be very careful in evaluating the tradeoffs between the capabilities, limitations, and requirements of alternative packages, on the one hand, and his agency's objectives, needs, and constraints, on the other hand. NETSSA can be very easily expanded to include additional software packages or updates of existing ones in its domain knowledge base.

Though NETSSA includes several important evaluation criteria, some may need additional refinements. For example, the modal split option of "full transit modeling" may require further detailed definition and classification. In addition, a particular user may want to consider additional criteria that may not currently be included in NETSSA. Further research and user comments should help identify additional criteria to be added to NETSSA. Furthermore, some evaluation criteria would be difficult to include and measure, such as "ease of use." That is, two packages may be capable of performing the same function (i.e., both satisfy a particular criterion), but one may be a lot easier compared to the other. NETSSA includes some "proxy" measures for "ease of use," but more enhancement is needed to explicitly consider this important criterion. It should also be very useful to test NETSSA against human experts involved in an actual process for software selection.

Future research for the development of expert systems for similar and related problems may prove to be fruitful. For instance, a similar software selection advisor is needed for site impact and corridor analyses. A more general expert system for the selection of transportation planning techniques to address a broader range of transportation problems would be a more challenging system to develop. In fact such an expert system may include NETSSA and similar systems as components.

ACKNOWLEDGMENTS

The authors would like to express their deep appreciation to Paul Hamilton, Tri-County Regional Planning Commission, Lansing, Michigan, and to George Dresser, Vergil Stover, and Duk Chang, Texas Transportation Institute, for their cooperation in providing the results of their invaluable studies. The comments of Walter Daugherity, Knowledge Systems Research Center, Texas A&M University, and TRB referees on the first version of the paper are greatly appreciated.

REFERENCES

1. M. Manheim. *Fundamentals of Transportation Systems Analysis: Volume I: Basic Concepts.* MIT Press, Cambridge, Mass., 1979.
2. *Microcomputers in Transportation: Software and Source Book.* UMTA, U.S. Department of Transportation, Washington, D.C., 1983, 1984, 1985, 1986, 1987, 1988.
3. D. Chang, V. Stover, and G. Dresser. *A Comparison of Microcomputer Packages for Network-Based Highway Planning.* Report 1110-3. Texas Transportation Institute, Texas A&M University, College Station, Tex., October 1988.
5. H. E. Pelt. Florida Standard Urban Transportation Model Structure. Presented at 1st Transportation Planning Applications Conference, Orlando, Fla., April 1987.
6. J. Gashing, R. Reboh, and J. Reiter. *Development of a Knowledge-Based Expert System for Water Resource Problems.* SRI International, Menlo Park, Calif., August 1981.
7. M. Maher, ed. *Expert Systems for Civil Engineers: Technology and Applications.* American Society of Civil Engineers, New York, N.Y., 1987.
8. F. Hayes-Roth, D. A. Waterman, and D. B. Lenat, eds. *Building Expert Systems.* Addison-Wesley, Reading, Mass., 1983.
9. C. Yeh, S. Ritchie, and J. Schneider. Potential Applications of Knowledge-Based Expert Systems in Transportation Planning and Engineering. In *Transportation Research Record 1076*, TRB, National Research Council, Washington, D.C., 1986.
10. P. Hamilton. *Michigan Microcomputer Traffic Forecasting Model Evaluation: Final Draft Comparison Matrix.* Tri-County Regional Planning Commission, Lansing, Mich., August 31, 1988.
11. A. Faghri and M. Demetsky. *A Demonstration of Expert Systems Applications in Transportation Engineering: Volume I: Transportation Engineers and Expert Systems.* Virginia Transportation Research Council, Charlottesville, Va., June 1987.

Publication of this paper sponsored by Task Force on Expert Systems.