

AD-A248 082



2

# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



DTIC  
ELECTE  
MAR 30, 1992  
S B D

# THESIS

A PROTOTYPE GRAPHICAL USER INTERFACE  
FOR  
CO-OP: A GROUP DECISION SUPPORT SYSTEM

by

P. Steven Posey

March 1992

Thesis Advisor:

Tung X. Bui

Approved for public release; distribution is unlimited

92-07839



92-07839

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				
1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY			3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release, distribution is unlimited	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE				
4 PERFORMING ORGANIZATION REPORT NUMBER(S)			5 MONITORING ORGANIZATION REPORT NUMBER(S)	
6a NAME OF PERFORMING ORGANIZATION Naval Postgraduate School		6b OFFICE SYMBOL (If applicable) 37		7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000			7b. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000	
8a NAME OF FUNDING/SPONSORING ORGANIZATION		8b OFFICE SYMBOL (If applicable)		9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code)			10 SOURCE OF FUNDING NUMBERS	
			Program Element No	Project No
			Task No	Work Unit Accession Number
11 TITLE (Include Security Classification) A PROTOTYPE GRAPHICAL USER INTERFACE FOR CO-OP. A GROUP DECISION SUPPORT SYSTEM				
12 PERSONAL AUTHOR(S) Posey, Paul Steven				
13a. TYPE OF REPORT Master's Thesis		13b. TIME COVERED From To		14 DATE OF REPORT (year, month, day) March 1992
				15. PAGE COUNT 89
16 SUPPLEMENTARY NOTATION The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
17 COSATI CODES			18 SUBJECT TERMS (continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUBGROUP		
			Graphical User Interface, Group Decision Support System, Co op, User Interface	
19. ABSTRACT (continue on reverse if necessary and identify by block number) A properly designed user interface has the potential to greatly enhance an application by reducing user effort and enhancing interaction. This thesis designs and develops a prototype Graphical User Interface (GUI) for Co op, a Group Decision Support System (GDSS) for Cooperative Multiple Criteria Group Decision Making. The GUI has been created in a Windows operating environment and intended to be used on an IBM compatible micro computer. Design methodology builds upon general interface design principles of User Control, Screen Design, and Screen Layout utilizing standard GUI control mechanisms.				
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS REPORT <input type="checkbox"/> DTIC USERS			21 ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a NAME OF RESPONSIBLE INDIVIDUAL Tung X. Bui			22b TELEPHONE (Include Area code) (408) 646-2630	
			22c OFFICE SYMBOL 5438J	

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted  
All other editions are obsoleteSECURITY CLASSIFICATION OF THIS PAGE  
UNCLASSIFIED

Approved for public release; distribution is unlimited.

A Prototype Graphical User Interface  
for  
Co-oP: A Group Decision Support System

by

P. Steven Posey  
Lieutenant, United States Navy  
B.S., University of Arkansas, 1985

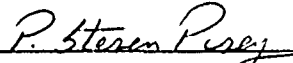
Submitted in partial fulfillment  
of the requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

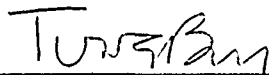
from the

NAVAL POSTGRADUATE SCHOOL  
March 1992

Author:

  
P. Steven Posey

Approved by:



Tung X. Bui, Thesis Advisor



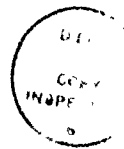
Balasubramaniam Ramesh, Second Reader



David R. Whipple, Chairman  
Department of Administrative Sciences

## ABSTRACT

A properly designed user interface has the potential to greatly enhance an application by reducing user effort and enhancing interaction. This thesis designs and develops a prototype Graphical User Interface (GUI) for Co-op, a Group Decision Support System (GDSS) for Cooperative Multiple Criteria Group Decision Making. The GUI has been created in a Windows operating environment and intended to be used on an IBM compatible micro-computer. Design methodology builds upon general interface design principles of User Control, Screen Design, and Screen Layout utilizing standard GUI control mechanisms.



Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

## TABLE OF CONTENTS

I.	INTRODUCTION . . . . .	1
A.	PURPOSE OF THESIS . . . . .	1
B.	BACKGROUND . . . . .	1
	1. System Overview . . . . .	1
	2. Model Components . . . . .	3
	3. Communications Module . . . . .	4
	4. Interface Component . . . . .	4
C.	SCOPE OF RESEARCH . . . . .	5
D.	THESIS ORGANIZATION . . . . .	5
II.	INTERFACE DESIGN PRINCIPLES . . . . .	7
A.	GRAPHICAL USER INTERFACES . . . . .	7
	1. Design Principles of Graphical User Interfaces . . . . .	8
	2. GUI Components . . . . .	8
B.	GENERAL DESIGN PRINCIPLES . . . . .	11
	1. User Control . . . . .	14
	a. Number of commands . . . . .	14
	b. Escape . . . . .	15
	c. Navigation . . . . .	15
	2. Screen Design . . . . .	16
	a. Color . . . . .	17

b. Screen Layout . . . . .	18
c. Typography . . . . .	19
C. GUI DESIGN CONSIDERATIONS FOR COOP . . . . .	19
1. Interpreting the Model . . . . .	20
2. Channeling Input . . . . .	22
3. Limiting Output . . . . .	22
4. Networking Issues . . . . .	22
III. INDIVIDUAL SCREEN DESIGNS . . . . .	25
A. MAIN CO-OP SCREEN . . . . .	25
B. GROUP PROBLEM DEFINITION MODULE . . . . .	27
1. Problem Identification Screen . . . . .	27
2. Problem Files Screen . . . . .	28
3. Problem Definition Screen . . . . .	28
4. Identification of Alternatives . . . . .	30
5. Hierarchy of Evaluation Criteria Screen . . . . .	32
C. GROUP NORM DEFINITION MODULE . . . . .	32
1. Group Norm Identification Screen . . . . .	34
2. Group Norm Files Screen . . . . .	34
3. Group Norm Definition Screen . . . . .	36
4. Identification of Group Members Screen . . . . .	36
5. Decision Makers Screen . . . . .	38
6. Group Decision Techniques Screen . . . . .	38
7. Individual Decision Weights Screen . . . . .	41
8. Individual Criteria Selection Screen . . . . .	41
9. Techniques of Aggregation Screen . . . . .	43

10.	The Information Exchange Screen . . . . .	46
D.	CRITERIA PRIORITIZATION MODULE . . . . .	46
1.	Prioritization of Evaluation Criteria Screen	48
2.	Pairwise Comparison Screen . . . . .	49
3.	Modification Technique Screen . . . . .	52
4.	Criteria Modification Screen . . . . .	52
5.	Statistical Evaluation Screen . . . . .	52
6.	Priority Vector Graph Screen . . . . .	54
7.	Direct Input of Criteria Weights Screen . .	54
E.	ALTERNATIVES EVALUATION MODULE . . . . .	57
1.	Evaluation of Alternatives Screen . . . . .	57
2.	Pairwise Comparison Screen . . . . .	57
3.	Modification Technique Screen . . . . .	59
4.	Alternative Modification Screen . . . . .	59
5.	Statistical Evaluation Screen . . . . .	59
6.	Priority Vector Graph Screen . . . . .	59
7.	Evaluation of Alternatives Using Electre Screen . . . . .	61
8.	Alternative Evaluation Screen . . . . .	61
9.	Direct Individual Evaluation Screen . . . . .	64
F.	DIRECT INDIVIDUAL EVALUATION MODULE . . . . .	66
G.	COMPUTATION OF GROUP DECISION MODULE . . . . .	66
1.	Computation of Group Results Screen . . . . .	66
2.	Cardinal Rankings Screen . . . . .	68
3.	Ordinal Rankings Screen . . . . .	68
4.	Group Results Screen . . . . .	70

H. IDENTIFY NEGOTIABLE ALTERNATIVES MODULE . . . .	70
I. MISCELLANEOUS SCREEN INTERFACES . . . . .	73
IV. SUMMARY AND RECOMMENDED FUTURE RESEARCH . . . . .	75
A. SUMMARY . . . . .	75
B. RECOMMENDED FUTURE RESEARCH . . . . .	75
LIST OF REFERENCES. . . . .	77
INITIAL DISTRIBUTION LIST . . . . .	78



## LIST OF FIGURES

Figure 1.	Original Four Window Design . . . . .	20
Figure 2.	Co-oP Main Screen . . . . .	26
Figure 3.	Problem Identification Screen . . . . .	29
Figure 4.	Problem Files Screen . . . . .	29
Figure 5.	Problem Definition Screen . . . . .	31
Figure 6.	Identification of Alternatives Screen . . .	31
Figure 7.	Hierarchy of Evaluation Criteria Screen . .	33
Figure 8.	Group Norm Identification Screen . . . . .	35
Figure 9.	Group Norm Files Screen . . . . .	35
Figure 10.	Group Norm Definition Screen . . . . .	37
Figure 11.	Identification of Group Members Screen . .	37
Figure 12.	Decision Makers Screen . . . . .	39
Figure 13.	Group Decision Techniques Screen . . . . .	40
Figure 14.	Individual Decision Weights Screen . . . .	42
Figure 15.	Individual Criteria Selection Screen . . .	44
Figure 16.	Techniques of Aggregation Screen . . . . .	45
Figure 17.	Information Exchange Screen . . . . .	47
Figure 18.	Prioritization of Evaluation Criteria Screen . . . . .	50
Figure 19.	Pairwise Comparison Screen . . . . .	50
Figure 20.	Pairwise Comparison Screen . . . . .	51
Figure 21.	Modification Technique Screen . . . . .	53
Figure 22.	Criteria Modification Screen . . . . .	53
Figure 23.	Statistical Evaluation Screen . . . . .	55

Figure 24.	Priority Vector Graph Screen . . . . .	55
Figure 25.	Direct Input of Criteria Weights Screen . .	56
Figure 26.	Evaluation of Alternatives Screen . . . . .	58
Figure 27.	Pairwise Comparison Screen . . . . .	60
Figure 28.	Alternative Modification Screen . . . . .	62
Figure 29.	Priority Vector Graph Screen . . . . .	62
Figure 30.	Evaluation of Alternatives Using Electre Screen . . . . .	63
Figure 31.	Alternative Evaluation Screen . . . . .	63
Figure 32.	Direct Individual Evaluation Screen . . . .	65
Figure 33.	Direct Individual Evaluation Screen . . . .	67
Figure 34.	Computation of Group Decision Screen . . .	69
Figure 35.	Cardinal Rankings Screen . . . . .	69
Figure 36.	Ordinal Rankings Screen . . . . .	71
Figure 37.	Group Results Screen . . . . .	72
Figure 38.	Help Screen . . . . .	74
Figure 39.	Error Screen . . . . .	74

## **I. INTRODUCTION**

### **A. PURPOSE OF THESIS**

The purpose of this research is to design a prototype Graphical User Interface (GUI) for Co-oP, a Group Decision Support System (GDSS) for Cooperative Multiple Criteria Group Decision Making. This user interface will substantially increase the value of the Co-oP model, "...as an experimental tool to evaluate the effectiveness of group Decision Support Systems in supporting group decision-making." [Ref. 1:p. 3], by developing an effective user-friendly interface that encourages broadened user participation.

### **B. BACKGROUND**

Co-oP was designed to study the possibility of creating a GDSS that supports both content-oriented and process-oriented decision techniques [Ref. 1:p. 117]. Furthermore it was to provide users with a communications network in order to support a distributed GDSS by setting up communications parameters and group norm definitions prior to initiating the group decision process.

#### **1. System Overview**

Co-oP is intended to be a microcomputer-based process-driven DSS in which each participant of the group has his own DSS whose model base is based on multiple criteria decision

methods (MCDM) along with additional personal DSS tools [Ref. 1:p. 118]. The GDSS contains sets of aggregation preferences techniques and consensus seeking algorithms that can be used with individual MCDMs. The microcomputer network system is to be linked together using Local area network [Ref. 1:p. 118]. Originally written in Turbo Pascal, a number of the Co-oP routines have been updated to C in 1987. In order to follow an unambiguous and uniform flow of information, Co-oP follows the basic steps of a multiple criteria problem solving process (see Chapter II, section C.1). First, the group must select and identify a decision problem. This includes determining the set of alternatives along with evaluation criteria. Secondly the group must identify members and set communication parameters. These parameters include data transfers, interactive conversation, utilization of electronic mail, and types of decision techniques [Ref. 1:pp. 121-124]. The third step involves individual evaluation prioritization. This includes methods of assigning weights to criteria directly, for example ELECTRE, or using a hierarchical prioritization scheme (e.g., Analytical Hierarchy Process). These methods can be utilized in a pooled mode in which all group members collectively enter a priority vector, or as single user DSS with communication support. The fourth process allows users to individually evaluate alternative using his preferred or familiar MCDM. In the current version, these methods include ELECTRE, the Analytical Hierarchy Process, or direct

individual ranking. The next step of the process is the computation of group results using four techniques of aggregation of preferences. If unanimity is not obtained, a consensus seeking algorithm can be evoked or the decision makers can revise their individual evaluations.

## **2. Model Components**

The main purpose of the MCDM model bank is to provide the decision makers a set of models that can solve the most common types of decision problems [Ref. 1:p. 126]. Co-oP contains three models that cover selection, ranking, and sorting. These methods are not difficult and interact with techniques of aggregation.

The ELECTRE method is characterized by circumventing the problem of incomplete comparability of alternatives through the concept of outranking relations [Ref. 1:p. 127]. Two reasons a decision maker finds it difficult to compare alternatives are the to uncertainty associated with measurements and evaluation, and incomparable alternatives.

The Analytic Hierarch Process (AHP) method supports complex decision problems by successively decomposing and synthesizing various elements of a decision situation [Ref. 1:p. 131]. AHP permits subjective and qualitative comparisons by measuring levels of priority in a pairwise relation, creating a reciprocal matrix of pairwise comparisons.

### **3. Communications Module**

Co-oP provides for the following functions: coordinate information exchange, enforce communication protocols, search for data compatibility for group algorithms, and sort data for diffusion [Ref. 1:p. 136]. A group norm constructor in Co-oP allows users to define a framework for communications exchange in support of the decision making process. The group users through the group norm agrees upon decision techniques, techniques of aggregation and which weighted majority rule to be complied with. Information exchange parameters such as broadcasting of outputs to selected users are supported. The group norm allows users to modify individual inputs and also sets a time limitation in which to submit inputs. In addition, a bulletin board or electronic notepad can be used as a format-free mechanism for group members to exchange ideas. To protect information, password identification is required by members of the group norm.

### **4. Interface Component**

The Co-oP interface was designed to provide a simple unambiguous and standard man-machine interface allowing users to concentrate on the core of the problem [Ref. 1:p. 140]. During the problem and group norm definition phases, a outline form data entry format is used. In the Pascal version of Co-oP, a typical screen format displays four different windows simultaneously. The Step window identifies current process

and displays any required diagnostic messages or prompts. The Dialogue window provides a conversational medium utilizing a Question/Answer mode of interaction. The Working window displays vital information from dialogue or inputs and displays other group members results. The Solution window displays immediate and final results in the format of tabular outputs, graphs, and statistical indexes. Co-oP also utilizes different colored screens and text to allow easy recognition of various displays. In order to provide the users with a structured, simple and controlled framework for the model, Co-oP combines menus and questions for communication with users.

#### **C. SCOPE OF RESEARCH**

The scope of this research includes the prototype design of a user interface for the Co-oP Group Decision Support System model utilizing a programming system for Windows environments. Interface design is patterned on current GUI standards. Individual screen designs will be discussed in depth as to their design methodology in relation to the Co-oP model.

#### **D. THESIS ORGANIZATION**

Chapter II reviews general design principles and specific design considerations for Co-oP. Chapter III presents individual screen designs and provides an in depth analysis of screen architecture, including limitations and benefits of GUI

guidelines in conveying current Co-op model requirements. Chapter IV provides a summary of findings and guidance for future considerations.



## II. INTERFACE DESIGN PRINCIPLES

### A. GRAPHICAL USER INTERFACES

Current trends in software applications are increasingly taking into account how the user will interact with the computer. According to Hooper [Ref. 2:p.9],

"In research on interface design we frequently allude to the creation of environments for enhanced interaction and problem solving."

Designers are now recognizing that along with new advances in hardware technology and expanded computing capabilities, that ultimately end user use determines how successful an application actually is. Hooper adds [Ref. 2:p.9],

"Similarly we often distinguish the aesthetics of an interface from its functionality, and we emphasize the importance of the satisfaction of a human user as a criterion for evaluation rather than the objective analysis of the technological power of a particular system."

In responding to human user satisfaction as a criterion for evaluation, and thus considered as part of design considerations, graphical interfaces are becoming the designers interface of choice. Popularized in 1984 by the Apple Macintosh, this type of interface has come to be known as Graphical User Interface (GUI) [Ref. 3:p.250].

## **1. Design Principles of Graphical User Interfaces**

Conveying information about data and functions visually allows designers the ability to accurately model applications.

According to Gaines and Shaw [Ref. 4:p.80],

"Users will model the computer system and form new expectations based on their interaction with it. The system should be designed to induce accurate models and correct expectations."

In order for a user to fully benefit from an application, he must first be able to interact with it. This interaction begins at the interface both in its controls and the way information is displayed. In modeling the application, the interface must be easy to understand. If the user has difficulties with understanding the application as a result of a complicated or incomplete computer interface, his attention is diverted from the application and his understanding of the problem or overall work effectiveness suffers. A properly designed graphical user interface parallels the application model both through control and data exchange. This alleviates user communication anxiety and allows him to concentrate on the task at hand.

## **2. GUI Components**

There are currently several organizations marketing graphical interfaces that share some but not all common features. Table 1 lists some of the larger GUI products along with their associated organizations. The following is a list of parts typically associated with a GUI [Ref. 3:p. 250];

- a pointing device, typically a mouse
- on-screen menus that can appear or disappear under pointing-device control
- windows that graphically display what the computer is doing
- icons that represent files, directories, and so on
- dialogue boxes, buttons, sliders, check boxes, and a plethora of other graphical widgets that let you tell the computer what to do and how to do it

Table 1. CURRENT GRAPHICAL USER INTERFACES

Organizations	Product
Apple	Macintosh
Microsoft	Windows
IBM with Microsoft	OS/2 Presentation
Digital Equipment Corp.	DECwindows
Open Software Foundation	Motif
Santa Cruz Operation (SCO)	Open Desktop
Commodore Amiga	Intuition
NeXT Computer	NeXTStep
Digital Research	GEM
Sun Microsystems	Open Look
Hewlett-Packard with Microsoft	Common X Interface
Hewlett-Packard	NewWave

Source: [Ref. 3]

Additionally the following is a list of some common GUI controls:

- Command button: Performs a task when chosen by the user. Some examples are the "OK" button, the "Cancel" button, and the "Enter" button.

- Check box: Displays an option that can be turned on or off. Check boxes may be used in groups to display multiple options.
- Option button: Sometimes referred to as the "radio button" displays an option that can be turned on or off.
- Combo box: This control allows the user to make a selection by typing text or selecting an item from the list below it.
- List box: Displays a list from which the user can choose one.
- Text box: Can either display information that is specified or that the user enters.
- Action bar: Also known as the Action Menu provides a means of displaying selectable drop down menu boxes.

Not all GUIs have all these features. Some may not accommodate a pointing device or lack visual features such as icons or other specific graphical devices. Hayes and Baran have identified three similarities [Ref. 3:p. 250],

"...most GUIs consist of three major components: a windowing system, an imaging model, and a application program interface (API)."

The windowing system is described as a set of programming tools and commands that are used to build interface windows and include the menus, controls, dialogue boxes, and commands that make up the interface. The imaging model defines the creation of fonts and graphics. Two examples are Macintosh's Quickdraw and Microsoft's Graphic Programming Interface for OS/2. The API is a set of programming function calls and is how the programmer specifies what graphics will appear on the screen.

While Hayes and Baran have defined a GUI in terms of three components, Myers identifies the user interface as a logical part of the window manager [Ref. 5:p. 67]. He identifies a base layer that implements the functionality of the windows manager. It consists of two parts, one to handle the display of graphics and a second part to access input devices. Termed the program interface or application, it has a primary purpose of interfacing with other programs. The second layer is the user interface. This is the visible layer and is further broken down into two parts. The layer associated with pictures or displays is termed presentation, and the layer which allows the user commands to manipulate controls is termed operations.

In the development of Co-op's prototype GUI, the representation of the underlying application is emphasized. According to IBM's Advanced Interface Design Guide, the designer of an interface provides the screen components which best support that application [Ref. 6:p.3]. In following current trends in emphasizing the visual interface as a means of encouraging user understanding and participation, this prototype GUI, being developed in Visual Basic, emphasizes the user's perspective in presenting an application.

## **B. GENERAL DESIGN PRINCIPLES**

Design guidelines for GUIs are not revolutionary but continuations of established principles. An interface should

present a clear, organized representation of the application it is conveying. Shneiderman identifies 8 underlying principles of design [Ref. 7:pp. 60-62];

- Strive for consistency
- Enable frequent users to use shortcuts
- Offer informative feedback
- Design dialogues to yield closure
- Offer simple error handling
- Permit easy reversal of actions
- Support internal locus of control
- Reduce short-term memory load

Consistency in an application includes controls, commands, actions, terminology, menus, and screen layout. By enforcing consistency, the designer is able to reinforce an application, allowing the user to concentrate on the problem as his interaction through the interface become secondary. The use of special keys and commands allow the knowledgeable users to reduce the number of interactions through shortcuts. Windowing interfaces can be easily manipulated by the experienced user to quickly navigate through an application. Visual feedback allows users to see consequence of actions, whether it be an error message or subtle change of color. Providing a sense of closure allow the user a feeling of accomplishment and termination to the current action and enables him to move on to the next action. Error handling should be simple. Provide detection mechanisms and easy

correction capability. The user should not worry that improper commands or input would adversely effect data. Easy reversal of actions allow the user to explore the system free from the anxiety of making mistakes that cannot be easily corrected or have adverse effect on the application. Allow the user to be in control. His actions should be by choice rather than responding to rigid sequential input. Reduce memory effort of the user by simplifying screens and sequence of actions. User actions should be obvious with appropriate help mechanisms to alleviate the amount of information the user must work with. These principles of dialogue design readily equate to the design of visual interfaces. The designer strives for an interface that is easy to control, simple to understand and will reinforce the users expectations of the application.

The enhancement of the user interface must convey an image of the application. Merely making an interface graphically appealing is not a means to making it more effective. Regarding the design of GUIs, Marcus notes [Ref. 8:p. 107];

"Graphic design can help GUIs achieve their potential to communicate. Information-oriented, systematic graphic design is the use of typography, symbols, color, and other static and dynamic graphics to convey facts, concepts, and emotions."

He further identifies three principles as a useful guide to research and development [Ref. 8];

- Organize: Provide the user with a clear consistent conceptual structure. This includes concepts of

consistency both in screen design and controls, and navigability through the application.

- Economize: Maximize the effectiveness of a minimal set of cues. Limit the number of controls to what is absolutely required and avoid unnecessary items.
- Communicate: Match the presentation to the capabilities of the user. Communicate through visualization by balancing aspects of color, text, and symbols in representing the application.

## 1. User Control

In designing the visual interface, mechanisms of control should be balanced to accommodate both the experienced user and novice. Shneiderman writes [Ref. 9:p. 226];

"A driving force in human behavior is the desire to control. Some individuals have powerful needs to attain and maintain control of their total environment; others are less strongly motivated in this direction and are more accepting of their fate."

In accommodating the users perspective, three issues should be addressed. They include the number of controls, escape, and navigation. In addition, and of major concern from most authors is the concept of consistency, Marcus relates it to both consistency in conventions and rules [Ref. 8]. In terms of control, make commands familiar with similar consequence of action and reinforce consistency across the entire application.

### *a. Number of commands*

Two factors are reinforced in terms of commands. Marcus writes, "Simplicity suggests that we include only those



elements that are essential for communication." [Ref. 10:p. 121]. Myers notes that a large number of commands allow users to perform functions many ways but it may add difficulty in knowing which command to use [Ref. 5:p.78]. Simply put, minimize the number of commands and make them clear as to function.

#### *b. Escape*

Another control aspect is the users ability to escape a command or action. Shneiderman discusses user anxiety in terms of user ability in using computer systems and their fear of altering data [Ref. 9:p. 225-226]. When interacting with an application a user, in order to be in control, should be able to exit or escape a function without fear of altering data. This capability allows him to explore system actions and capabilities without fear of data corruption. As stated by Gaines and Shaw, "There should be a facility to enable the user to escape at will leaving the state of the system well defined." [Ref. 4:p. 81].

#### *c. Navigation*

The user must be able to develop a sense of control over his actions, which includes both the concept of escape as previously described but also a sense of controlling subsequent actions. If the user for any reason needs to terminate an action or return to a previous application module, he should be provided that mechanism. Being caught in

a loop requiring user input before termination removes that sense of control. The application should avoid traditional modes of sequential input that restrict user interaction to a rigidly prescribed routing and allow the user to control or navigate through the application as it best meets his needs.

## **2. Screen Design**

The importance of the user interface relates directly to what the user sees. A effective screen design assists rather than hinders the users understanding of the application. The use of graphical displays enhance user visualization. The designer must also curtail graphics as if they are overdone, they can overpower the user and complicate his problem understanding. According to Marcus, "You must select visualization techniques that are appropriate to the output display technology." [Ref. 10:p. 122]. He further identifies aspects of legibility, readability, typography, symbolism, view, and color. Three areas pertaining to a graphical interface need attention, color, screen layout, and typography. As in user controls, consistency is required across screen design. IBMs Advanced Interface Design Guide notes that users become familiar with interface components when the visual appearance of these components are consistent across applications [Ref. 6:p. 11].

### a. Color

Marcus notes the use of color in graphical interfaces greatly enhances problem presentation if used correctly [Ref. 11:p. 135]. He adds, "Conversely, the inappropriate use of color can seriously reduce the functionality of a display system.". Marcus identifies three principles of color design: color organization, color economy, and color communication. Consistency, as in most designs, guides organization. The use of similar colored backgrounds, controls, and cues allow the user to associate common displays. In presenting screens to users, avoid overly dazzling, multicolored displays. Restrict the number of colors to  $5 \pm 2$  for simplicity [Ref. 11:p. 137]. Allow colors to communicate. Subtle color change add accents and separate areas of display. Contrasting colors are attention getters and could be used to draw focus for emphasis or warning. Shneiderman points out several guidelines for designers in relation to color use [Ref. 7:pp. 337-342]:

- Use color conservatively
- Limit the number of colors
- Recognize the power of color as a coding technique
- Color coding should support the task
- Color coding should appear with minimal user effort
- Color coding is under user control
- Design for monochrome first
- Color can help in formatting
- Be consistent in color coding

- Be alert to common expectations about color codes
- Use color changes to indicate status changes
- Use color in graphic display for greater information density
- Beware of the loss of resolution with color displays

The bottom line in adding color to screen design is to use it to augment or highlight information, not over power the user with excess.

#### *b. Screen Layout*

Design considerations relating to screen layout include consistency, format, and user memory. As previously noted, consistency across screen designs needs to include layout. Common positioning of controls, text, menus, and forms all lead to ease of comprehension for the user. By enforcing consistency, the user, in becoming familiar with format, spends less time with the physical display and more time concentrating on the actual application. Designing format that is natural to what the user expects contributes to his ease of interaction. Neat forms, proper alignment, and simple labeling that reflect the problem all lead to ease of use. Avoid over powering the user with excessive clutter. Regarding screen layouts, Marcus advises the use of a grid structure, standard screen layouts, a group-related elements [Ref. 8]. Provide only the controls and displays that are needed by the applications current data exchange requirements. The way the screen is spatially organized as in color, can

help or hinder the user interaction. The use of menus, controls, and dialogue should be limited to current application requirements.

### *c. Typography*

Typography consists of the typefaces and groupings of text in screen design. Marcus notes that one of the key elements to legibility and readability is the use of typography in design of the user interface [Ref. 10:p. 123]. He further suggests to limiting typefaces to a maximum of three. The typeface chosen should be legible and distinctive and not be hidden in background clutter.

## **C. GUI DESIGN CONSIDERATIONS FOR COOP**

Interpretation of the Co-oP model is in large part based on the current version's interface. Utilizing traditional menu format combined with sequential queries, it is rigidly structured. The interface itself is divided into four windows, the Step window, the Dialogue window, the Working window, and the Solution window [Ref. 1:pp. 141-143]. See Figure 1.

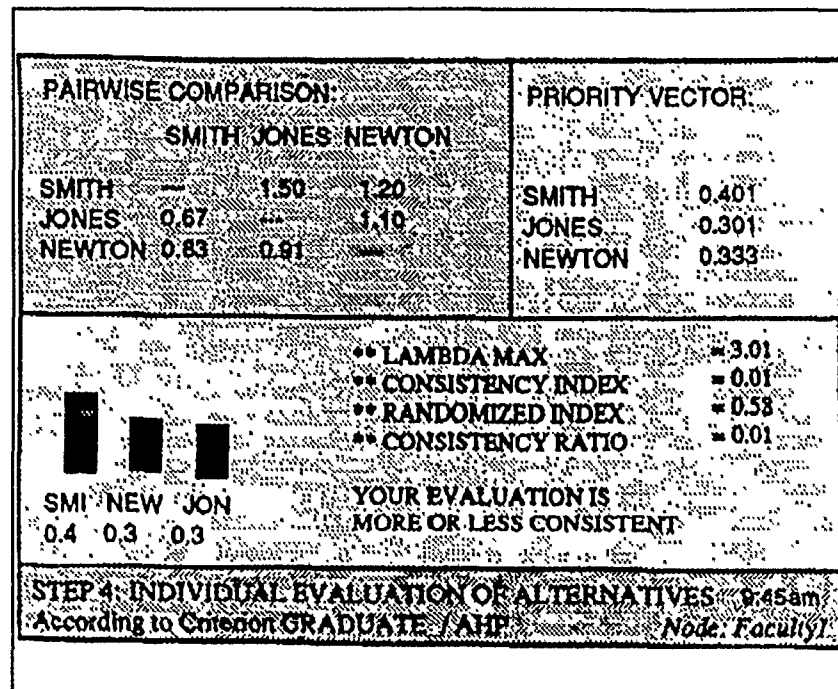


Figure 1. Original Four Window Design

Source: [Ref. 1:p. 143]

A primary concern in re-designing this interface is the incorporation of mechanisms allowing user control and establishing visual feedback specific to inputs requested by the user. Also mechanisms designed to alert the user to errors, and provide adequate help dialogues to assist him in utilizing the model through the interface.

### 1. Interpreting the Model

In interpreting the model, preservation of the multiple criteria decision method and other decision tools was paramount. Following the original interface, an appropriate way to insure required information flow is to follow a

multiple criteria problem solving process [Ref. 1:p. 120].

This process consists of:

- (i) Group Problem Definition
- (ii) Group Norm Definition
- (iii) Individual Prioritization of Evaluation Criteria
- (iv) Individual Evaluation and Selection of Alternatives
- (v) Direct Evaluation of Alternatives
- (vi) Group Selection of Alternatives using techniques of aggregation of preferences
- (vii) Consensus seeking and negotiation analysis

Note that step (v) may be substituted for steps (iii) and (iv). This general format remains unchanged. The first step is collectively identifying and defining the problem and secondly identifying the group members and determining communication restrictions. The third step allows two methods of prioritizing evaluation criteria. The user chooses either the AHP or direct method of ranking. Step (iv), evaluation of alternatives offers the AHP method, ELECTRE, and direct ranking to rate alternatives. As pointed out, step (v) may be substituted for both previous steps. Using four aggregation preferences, step (vi) computes group results. Finally, step (vi) permits a consensus seeking algorithm if a unanimous decision is not obtained.

## **2. Channeling Input**

In determining Interface design, input choices require careful thought. With numerous input devices such as simple text boxes, drop-down list boxes, or scrolling methods, to mention just a few, the method chosen is needed to reflect as much as possible what the user's mental image of Co-oP model dictated. Persistent to allowing the user to be in control, input mechanisms need to be broken down into steps easily understood and concentrated on and allowing a means of escape when completed [Ref. 9:p. 225]. This allows the user to break down input mechanisms into smaller, easily managed portions.

## **3. Limiting Output**

In designing for output, a major consideration was limiting information presented to the user. The combination of tables, matrixes, and graphs, as presented in the original interface tend to overpower the interface display and present a cluttered appearance. Limiting output to user requests again allow him to control presentations, and allow him to determine output requirements that meet his needs. In striving to meet this criteria, multiple, overlapping windows that are easily selected by the user enable customization of output that best serve his requirements.

## **4. Networking Issues**

Design of a DSS to support multiple decision making should also consider the developing technologies of computer networks



and electronic communication [Ref. 1:p. 35]. Characteristics of distributed systems allow individual users the ability to process applications of a group decision support system that is independent of network technology. Bui identifies six possible types of DSS user interactions [Ref. 1:pp. 39-42]:

- Type 1: The traditional DSS paradigm with the user interacting directly with an individual DSS with no communications support.
- Type 2: A group of users interacting with a DSS, usually with an intermediary.
- Type 3: Essentially a combination of the previous two in which each user interacts directly with an individual DSS with the addition of some type of electronic aggregation of preferences.
- Type 4: This DSS framework addresses the sharing of a GDSS but is loosely coupled and individuals lack knowledge about other group members.
- Type 5: This GDSS supports both individual DSS and group DSS as it provides a multilateral network relationship of shared DSS.
- Type 6: This GDSS, as in the previous type represent a distributed problem solving system with individual members interacting with the system. Additionally Type 6 provides for a mediator.

A networked GDSS can provide four main functions [Ref. 1:p. 45]:

- (i) monitoring of data exchange
- (ii) automatic selection of appropriate group decision techniques
- (iii) computation and explanation of a group decision
- (iv) suggestion for a discussion of individual differences or for a redefinition of the problem if attempts to reach consensus fail

The provision of networking in a GDSS allows for geographical dispersion of individual members. Communication can be either on-line or sequential, thus removing requirements for set times of participation and allowing each member the ability to interact at his convenience.

### III. INDIVIDUAL SCREEN DESIGNS

#### A. MAIN CO-OP SCREEN

This initial screen design titled, Cooperative Multiple Criteria Group Decision Maker, is the user interface to the Co-op model (see Figure 2). Each labeled Command Button identifies one of the models seven problem steps and when clicked, opens that particular sub-module. The design itself represents a flow chart of how the problem is to proceed. The first two steps of a problem are the definition of problem alternatives along with criteria for measurement, and defining the group norm which includes identifying members and communication parameters. These first two steps must be completed before continuing the problem. The model then allows two courses of action, the first is to utilize the various model components to prioritize criteria and evaluate alternatives. An alternate second method, if chosen, allows the user to rank alternatives directly without going through formal alternative evaluations. Both These two methods lead into the group decision button which opens that module and the identifying of negotiable alternatives. The final command button exits the program. Command Buttons were chosen as a graphical representation of the flow of the Co-op model over traditional menu driven selections. By presenting an overall

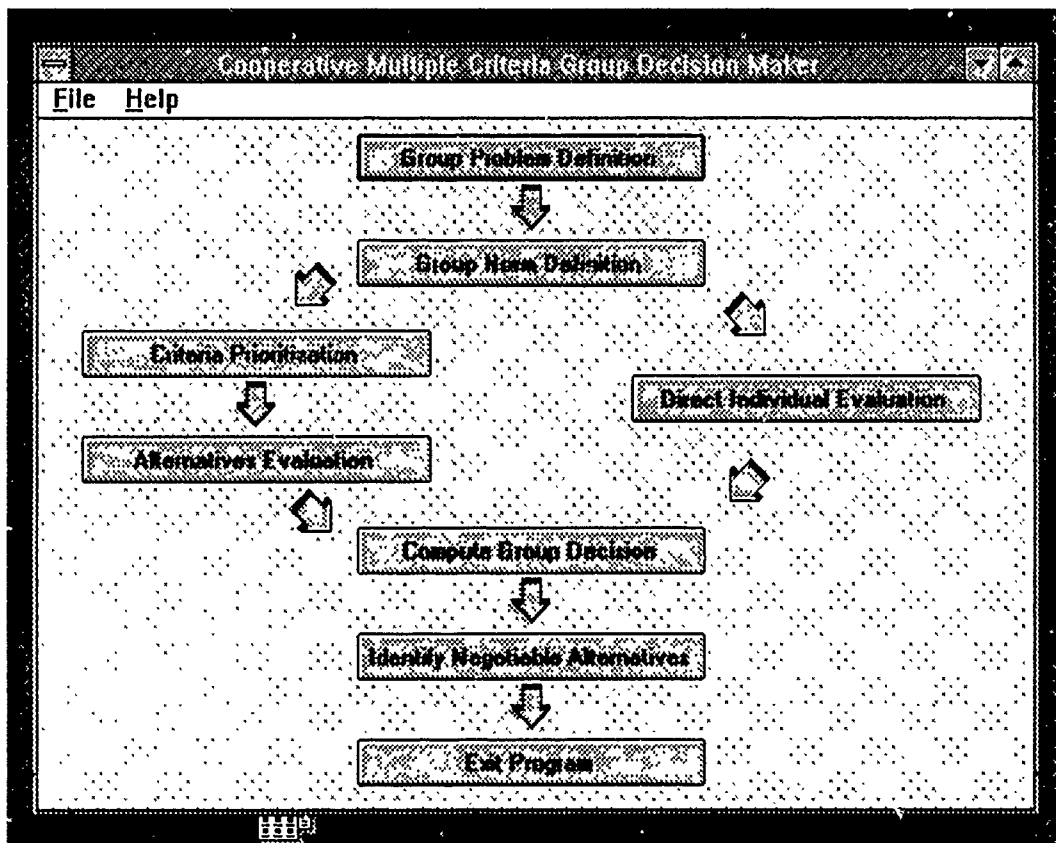


Figure 2. Co-oP Main Screen

visual display of the application model steps, the user should gain an immediate understanding of model requirements and a sense of control over his actions. Additionally, two menu items are available from the Action Bar. The File menu provides choices relating to document saving by access to a dialogue box and an additional exit selection. The Help menu provides choices of a general help screen and data about the interface.

## **B. GROUP PROBLEM DEFINITION MODULE**

This module correlates to step (i) of the Co-oP application (see page 20). The current prototype module contains five main screens. Three screens are dialogue boxes with minimal information requested from the user. The remaining two screens requiring the user to define both problem Alternatives and Evaluation Criteria, involve text input. In addition there are various additional Help, Password, and Dialogue boxes that will be covered in miscellaneous screen designs.

### **1. Problem Identification Screen**

This simple dialogue box allows the user to select via radio buttons whether he desires to define a new Group Problem or open a previously defined Group Problem (see Figure 3). The OK button accepts whatever choice he makes and the Cancel Button returns the user to the Main screen without accepting

any user input. The default selection is to define a new Group Problem.

## **2. Problem Files Screen**

This interface allows the user to select a previously defined problem file for use in his current application session (see Figure 4). It contains visual fields indicating current drive, directory, and associated problem files that are restricted to files with a .def extension. All data relating to the problem definition will be maintained in this file. In addition current path is displayed in a text box for the users reference. The user has a choice of three Command buttons. The OK command button selects user file selection. The Cancel button accepts no file and returns the user to the Problem Identification screen. And finally the Help button, which is intended to access an informative screen guidelines dialogue box.

## **3. Problem Definition Screen**

This screen interface allows the user to select either Identification of Alternatives or the Evaluation Criteria Hierarchy selection via radio buttons (see Figure 5). This dialogue box allows the user to enter the Problem Name if a new problem is to be defined or display the problem name if a previous problem was selected via a text box. The OK button accepts user choice with the Identification of Alternatives as

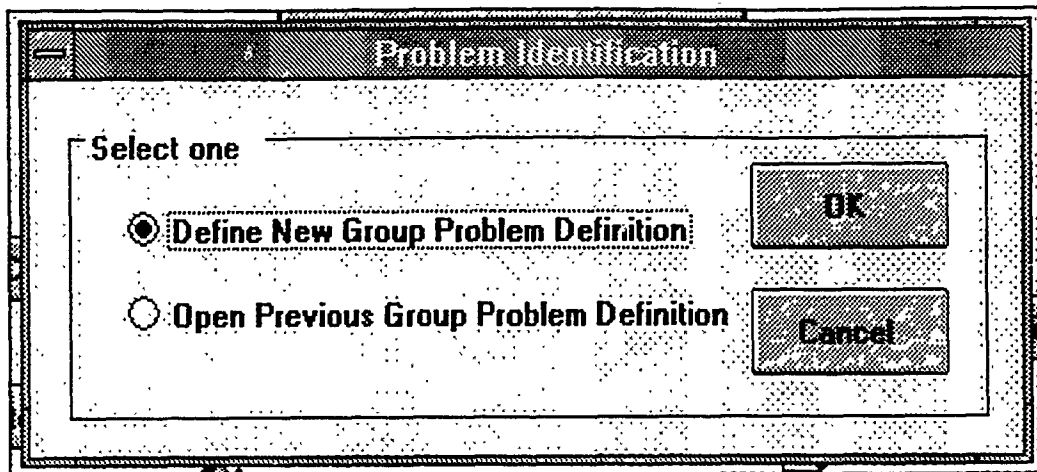


Figure 3. Problem Identification Screen

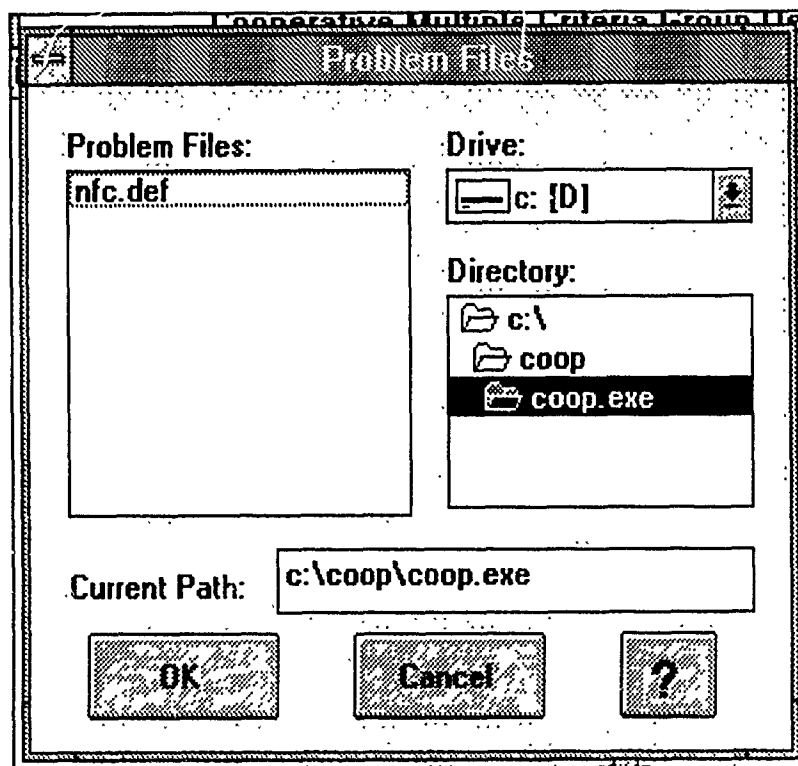


Figure 4. Problem Files Screen

the default value and the Cancel button returns the user to the Problem Identification screen. Additionally, this screen has File and Help menus accessed through an action bar. These additional dialogue box functions will be discussed in general in miscellaneous screen designs.

#### **4. Identification of Alternatives**

This screen allows the user to input up to 15 alternatives for the group to evaluate (see Figure 6). In determining the number of alternatives, screen limitations in the design software aesthetically limited this prototype to 15 choices. Ideally the number of alternatives should allow up to 40 choices. The Group Problem Name is automatically displayed for reference at the top of the display in a text box. The screen is formatted for up to 15 choices, of which only two are initially displayed, the rest being hidden until the user selects additional alternatives to enter via an Add Alternative Command button. Conversely, if the user wishes to eliminate alternatives he can use a Delete Alternative button to remove in reverse order, his number of choices. The Enter button accepts user input while the Cancel button returns the user to the Problem Definition screen display. This screen also introduces a Help button with the "?" caption. By utilizing a Command button for additional help screen access, it is graphically incorporated into the screen format vice having a single Help menu option on an action bar.



**Problem Definition**

File Help

Enter Problem Name:

Select one

☒ Identification of Alternatives

☐ Evaluation Criteria Hierarchy

Figure 5. Problem Definition Screen

**Identification of Alternatives**

Group Problem Name:

Enter Alternatives:

1.	alternative1	2.	alternative2
3.	alternative3		

Figure 6. Identification of Alternatives Screen

## **5. Hierarchy of Evaluation Criteria Screen**

This screen interface allows the user to input via text boxes a hierarchy of evaluation criteria (see Figure 7). There are three levels of hierarchy with up to ten choices available at each level. The default display is the first level indicated by the three Radio buttons in the Select Level frame box. Additionally, if further levels of detail are required for criteria evaluation, the user can select a second or third level which is based on the previous levels selection number. An additional dialogue box corresponding to that level will overlay the current window and allow for similar format of data entry allowing further amplification of user input relating to current level selected. The default selection is to define a new Group Problem. The Group Problem Name is displayed for user reference in a text box near the top of the screen. The enter button accepts inputs and the Cancel button returns the user to the Problem Definition Screen. As in the previous screen design, Add Criteria and Delete Criteria allow the user to modify the number of criteria for input.

### **C. GROUP NORM DEFINITION MODULE**

This module corresponds to step (ii) of the Co-op application (see page 20). This current prototype module contains ten primary screen interfaces. Four of the screen designs are dialogue boxes with minimal input required from

**Hierarchy of Evaluation Criteria**

Group Problem Name:

1.	Cost
2.	Maintenance
3.	Documentation
4.	Capability
5.	

**Select Level**

☒ 1st Criteria Level  
☐ 2nd Criteria Level  
☐ 3rd Criteria Level

**Enter**

**Cancel**

**?**

**Add Criteria**      **Delete Criteria**

Figure 7. Hierarchy of Evaluation Criteria Screen

the user. Two screens require text input that use an updated fill-in-the-blank format. The remaining four screens utilize either radio button or check box functions for user input. Screen formats were designed to focus the user on current data exchange requirements without excessive screen clutter.

#### **1. Group Norm Identification Screen**

This screen interface is similar in design to the Problem Identification screen on page 26, (see Figure 8). The user is given a choice of defining a new group norm or selecting a previous definition via radio button selection. The OK button accepts user input and the Cancel button returns the user to the Main Co-oP screen. The definition of a new group is the default.

#### **2. Group Norm Files Screen**

The user is allowed to retrieve a previously defined group norm for the current session (see Figure 9). Utilizing the same layout as the Problem Definition Screen (see page 27), it has visual references to the drive, directory, and corresponding files with a .GN extension. All data pertaining to the Group Norm parameters will be maintained in this file. Additionally, the current path is displayed for user reference. The command button OK accepts the highlighted group norm file for manipulation. The Cancel button returns the user to the Group Norm Identification Screen without

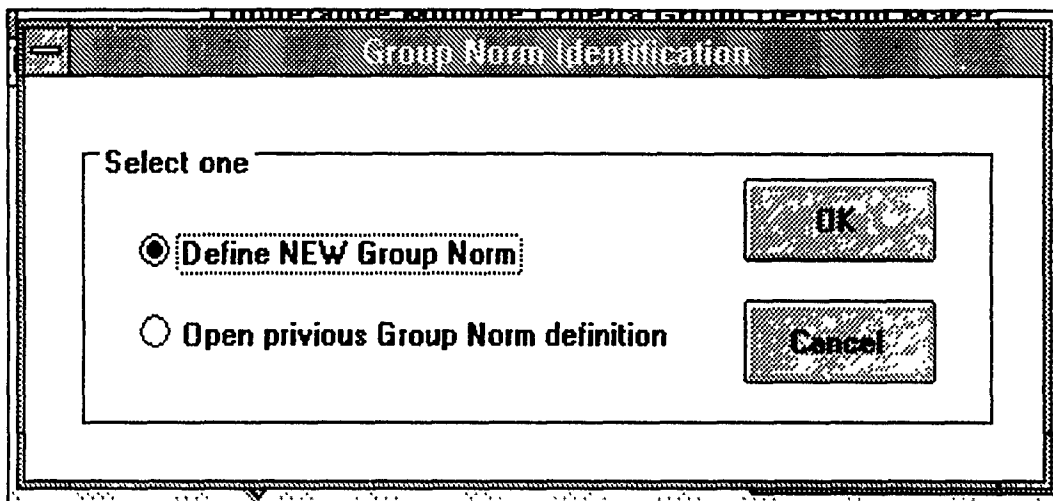


Figure 8. Group Norm Identification Screen

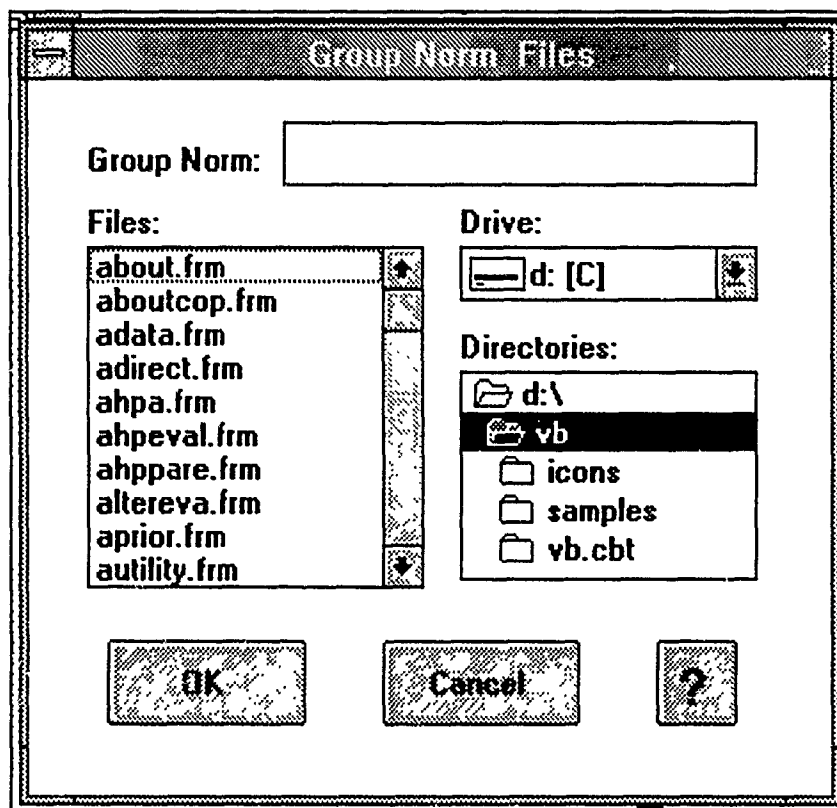


Figure 9. Group Norm Files Screen

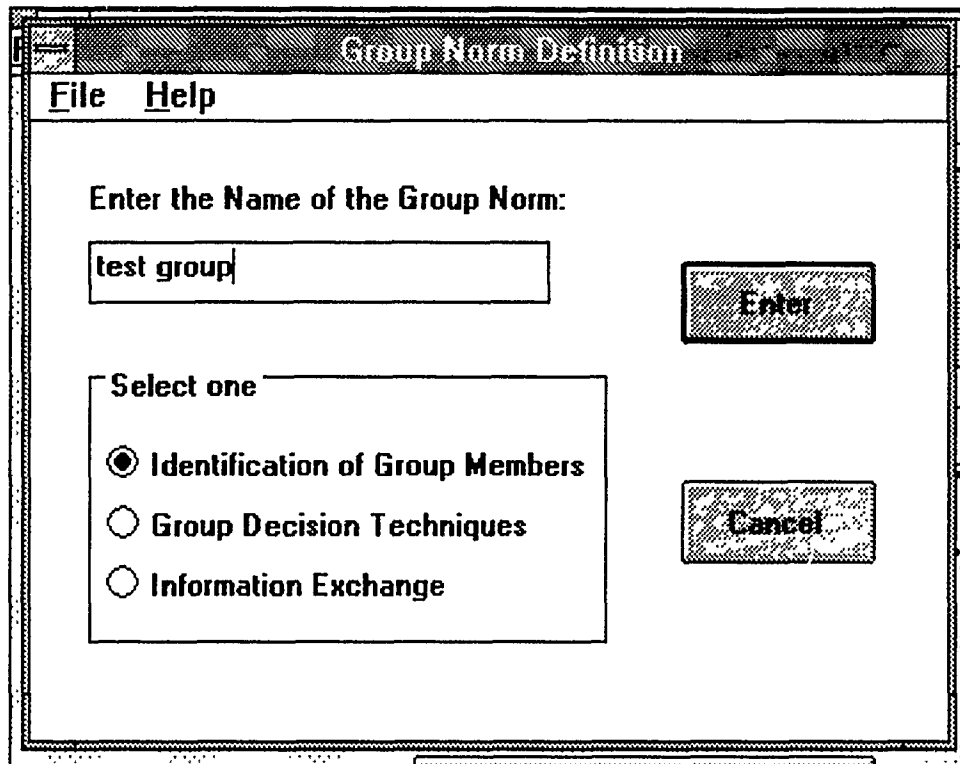
accepting any input. The Help button "?" will provide access to help documentation.

### **3. Group Norm Definition Screen**

This interface functions much the same way as the Problem Definition Screen (see page 27). Through radio button selection, the user is able to select either Identification of Group Members, Group Decision Techniques, or Information Exchange (see Figure 10). If not a previously defined group norm, the user enters a group norm name in the text box provided. The Enter button accepts the users radio button selection and displays that corresponding screen interface. The Cancel button returns without accepting any data to the Group Norm Identification Screen. When the user completes selection and data input of all three radio button options, a dialogue will prompt him to save that data. Two additional controls, a File menu selection and a Help menu selection are located on an action bar at the top of the screen.

### **4. Identification of Group Members Screen**

This dialogue box is displayed when the user selects the first radio button on the Group Norm definition screen. It consists of three text boxes (see Figure 11). The first text box allows the user to identify the Group Norm builder. The second input is a five character group password. The last input is the number of decision makers in the group. The



**Group Norm Definition**

File Help

Enter the Name of the Group Norm:

test group

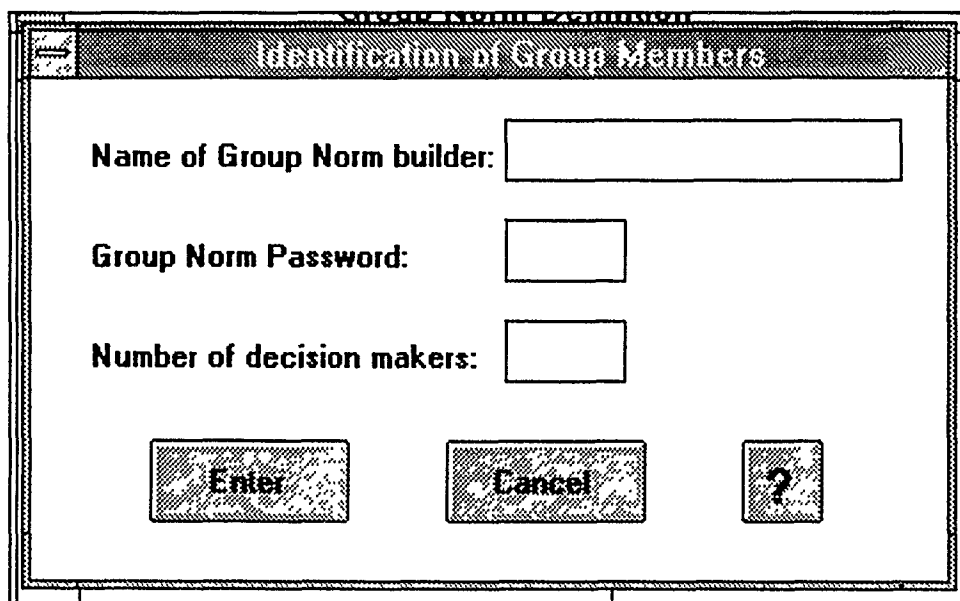
Enter

Select one

- ☒ Identification of Group Members
- ☐ Group Decision Techniques
- ☐ Information Exchange

Cancel

Figure 10. Group Norm Definition Screen



**Identification of Group Members**

Name of Group Norm builder:

Group Norm Password:

Number of decision makers:

Enter Cancel ?

Figure 11. Identification of Group Members Screen

Enter button accepts data input and the Cancel button returns the user to the Group Norm Identification screen.

#### **5. Decision Makers Screen**

This screen interface consists of simple text input into appropriate text boxes (see Figure 12). Up to 15 group members are allowed. Although 15 members are available, only the appropriate number of text boxes required are visible as indicated by the third input on the previous screen, the remaining unused text boxes remain invisible. Selection of the Enter command button accepts the group list and the Cancel button returns the user to the Identification of Group Members screen.

#### **6. Group Decision Techniques Screen**

Through this screen interface, the user defines the framework for the group decision techniques (see Figure 13). Specific areas covered include:

- weighing members input
- restricting the members input based on his area of expertise
- members decision technique to be used in group decision
- selection of techniques of aggregation of preference
- computation of NAI

The interface allows, via radio button selection, the members to set up decision techniques before continuing with an individual session. Radio button default values are displayed in individual frame boxes. If, as a result of button



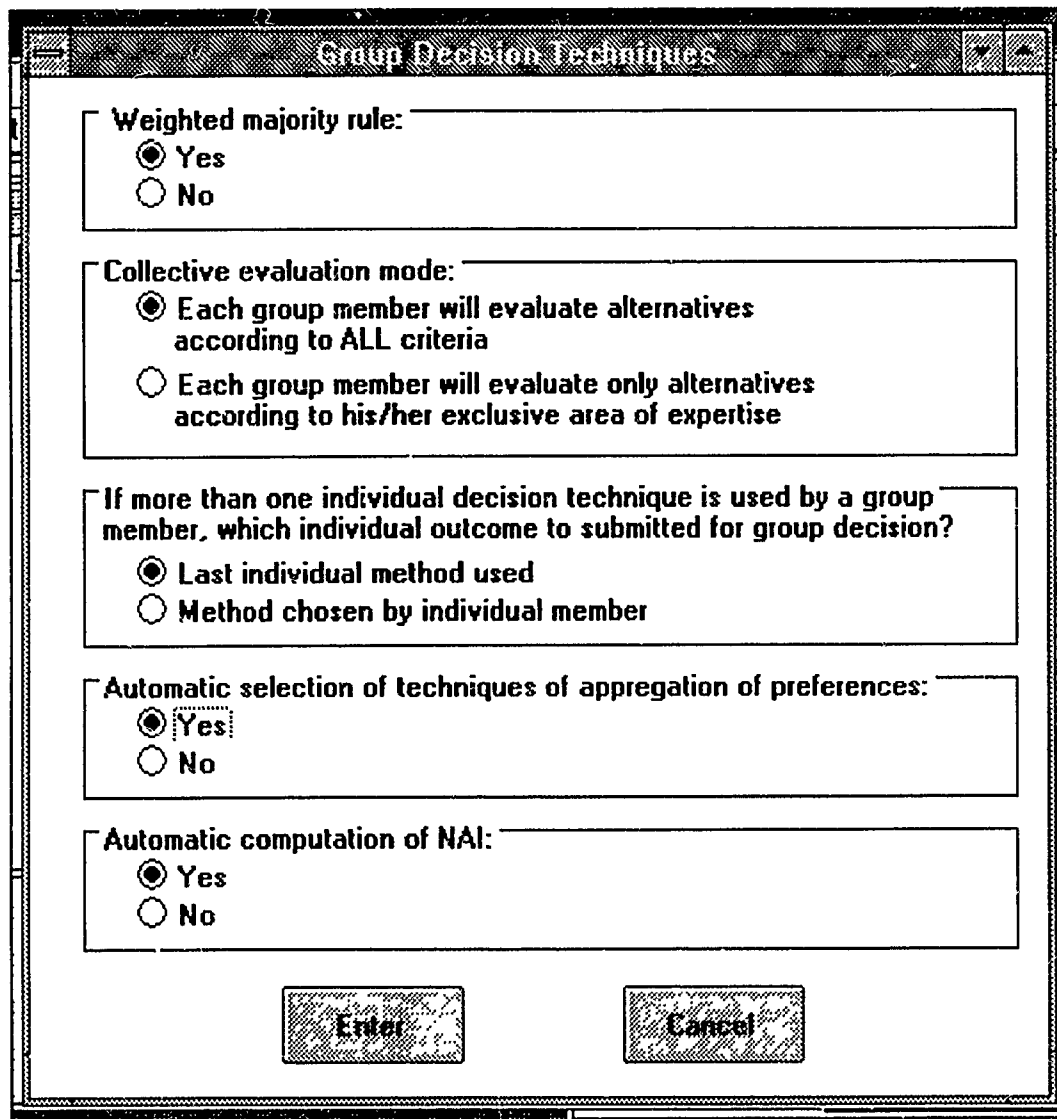
Decision Makers

Enter individual names:

1	member 1	2	member 2
3	member3	4	member4

Enter Cancel ?

Figure 12. Decision Makers Screen



The image shows a software window titled "Group Decision Techniques". It contains five sections, each with a label and a set of radio buttons. The first section is "Weighted majority rule:" with "Yes" and "No" options. The second is "Collective evaluation mode:" with two options: "Each group member will evaluate alternatives according to ALL criteria" and "Each group member will evaluate only alternatives according to his/her exclusive area of expertise". The third is "If more than one individual decision technique is used by a group member, which individual outcome to submitted for group decision?" with "Last individual method used" and "Method chosen by individual member" options. The fourth is "Automatic selection of techniques of appregation of preferences:" with "Yes" and "No" options. The fifth is "Automatic computation of NAI:" with "Yes" and "No" options. At the bottom are "Enter" and "Cancel" buttons.

**Group Decision Techniques**

**Weighted majority rule:**

- ☒ Yes
- ☐ No

**Collective evaluation mode:**

- ☒ Each group member will evaluate alternatives according to ALL criteria
- ☐ Each group member will evaluate only alternatives according to his/her exclusive area of expertise

**If more than one individual decision technique is used by a group member, which individual outcome to submitted for group decision?**

- ☒ Last individual method used
- ☐ Method chosen by individual member

**Automatic selection of techniques of appregation of preferences:**

- ☒ Yes
- ☐ No

**Automatic computation of NAI:**

- ☒ Yes
- ☐ No

**Enter** **Cancel**

Figure 13. Group Decision Techniques Screen

selection, further amplification is required, additional screens will overlay the current screen requesting additional input. The Enter button accepts the data input and the Cancel button returns the user to the Group Norm definition screen. Help mechanisms are not available as the text is self explanatory.

#### **7. Individual Decision Weights Screen**

This screen is displayed when the "No" radio button is selected for weighted majority rule. By default, each group members inputs are weighted equally. This interface allows the group members (up to 15) to be assigned different decision input weight. The actual weights can be either input directly by the group or manipulated through sliding boxes that incrementally increase or decrease a members decision weight factor (see Figure 14). Selection of the Enter button accepts input and the Cancel button returns the user to the Group Decision Techniques screen. In addition a Help button would allow additional amplification of how to input and manipulate the sliding boxes.

#### **8. Individual Criteria Selection Screen**

This screen, as in the Individual Decision Weights screen, appears as result of not selecting the default choice in the collective evaluation modes frame box. The default value allows each member to evaluate alternatives based on all criteria. Although not available in the current version of

Individual Decision Weights					
Name	Weight				
		▲			▲
		▲			▲
		▲			▲
		▲			▲

Enter

Cancel

?

Enter

Cancel

Figure 14. Individual Decision Weights Screen

Co-oP, this capability, included as part of the prototype interface allows the group to selectively choose areas of expertise for individual members to evaluate alternatives. The screen is designed to allow the group to easily select criteria for evaluation for each individual member who is identified by number (see Figure 15). Check boxes can either represent individual areas of criteria to be included or as areas to be suspended for that particular member. Only the first criterion layer is to be available for selective areas of expertise. Selection of the Continue button accepts agreed data and Cancel returns the user to the Group Decision Techniques screen. The addition of a help button is intended to allow for the addition of help dialogue in explaining input format.

#### **9. Techniques of Aggregation Screen**

The default value in determining techniques of aggregation of preferences are to utilize all four methods which include:

- SUM-OF-RANKS
- SUM-OF-OUTRANKING-RELATIONS
- ADDITIVE RANKING
- MULTIPLICATIVE RANKING

The group can choose to individually select each method through the Technique of Aggregation Screen. This screen interface allows the user to select, via radio buttons whether to enable techniques of aggregation (see Figure 16). The

Criteria	1	2	3	4	Members
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Continue Cancel ?

Figure 15. Individual Criteria Selection Screen

**Techniques of Aggregation**

**SUM-OF-RANKS**

☒ Yes  
☐ No

**SUM-OF-OUTRANKING-RELATIONS**

☒ Yes  
☐ No

**ADDITIVE RANKING**

☒ Yes  
☐ No

**MULTIPLICATIVE RANKING**

☒ Yes  
☐ No

**Enter** **Cancel**

Figure 16. Techniques of Aggregation Screen

Enter button accepts user input and the Cancel button returns the user to the Group Decision Techniques screen.

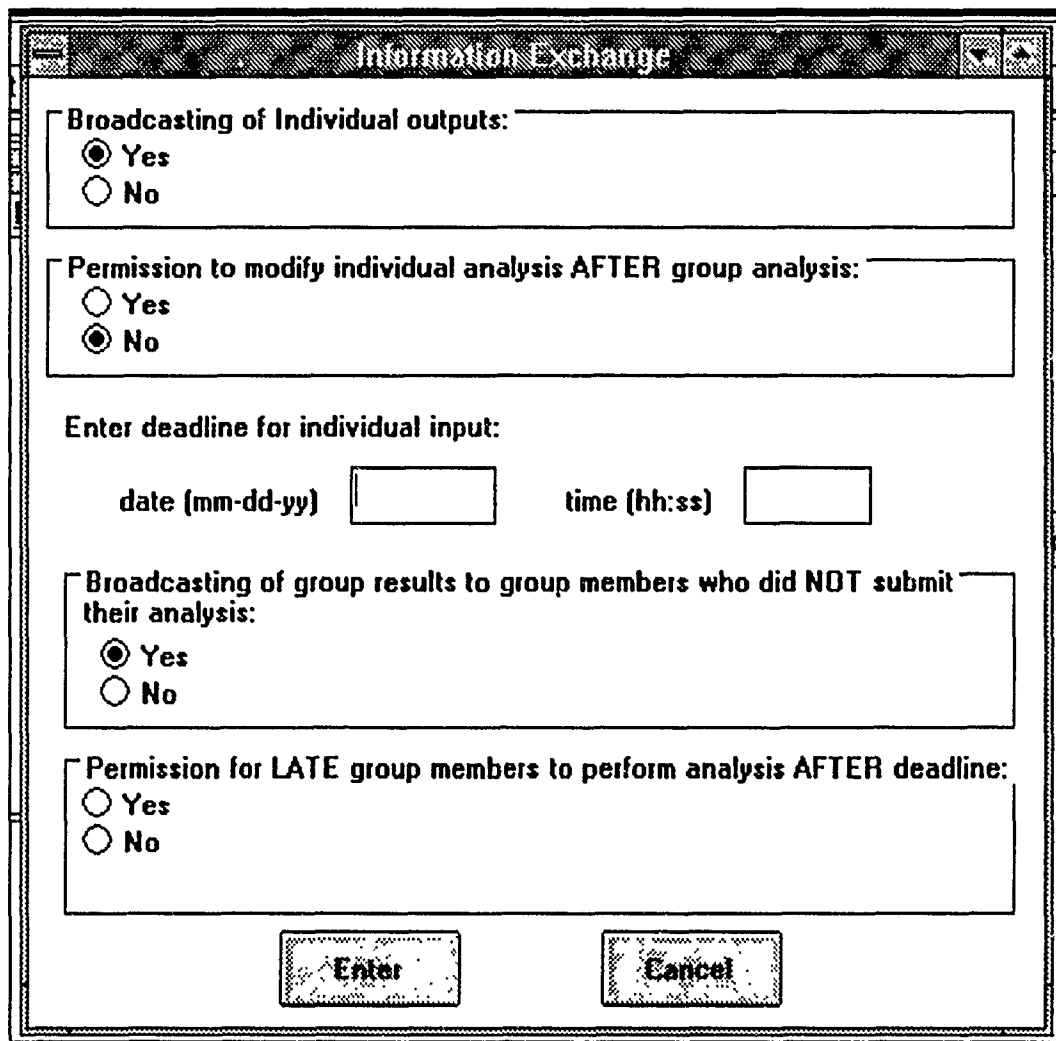
#### **10. The Information Exchange Screen**

This final screen interface is displayed when the user chooses the third radio button in the Group Norm Definition screen. It allows group members to set various communication parameters as the group norm is defined. Radio buttons allow either positive or negative answers to specific questions and two text boxes allow date and time entry with the format indicated (see Figure 17). The enter button accepts imputed data and the Cancel button returns the user to the Group Norm Definition screen.

#### **D. CRITERIA PRIORITIZATION MODULE**

As part of the Co-oP application, each group member is allowed to rank the problems evaluation criteria. This module allows group individuals two methods in accomplishing that process. The group user may choose the method of Pairwise Comparison, otherwise known as the Analytic Hierarchy Process (AHP). If the user does not require a formal decision tool, he may alternately choose a method of direct entry of priorities. A major design consideration for this module interface requires focusing screen presentation to the current input task at hand. This consideration is essential when utilizing pairwise comparison. This decision support tool allows the user to compare and evaluate two alternatives at a





The image shows a Windows-style dialog box titled "Information Exchange". It contains several sections for configuration. The first section, "Broadcasting of Individual outputs:", has two radio buttons: "Yes" (selected) and "No". The second section, "Permission to modify individual analysis AFTER group analysis:", has two radio buttons: "Yes" and "No" (selected). Below these is a section for "Enter deadline for individual input:", which includes two text input fields labeled "date (mm-dd-yy)" and "time (hh:ss)". The third section, "Broadcasting of group results to group members who did NOT submit their analysis:", has two radio buttons: "Yes" (selected) and "No". The fourth section, "Permission for LATE group members to perform analysis AFTER deadline:", has two radio buttons: "Yes" and "No". At the bottom of the dialog are two buttons: "Enter" and "Cancel".

**Information Exchange**

Broadcasting of Individual outputs: ☒ Yes ☐ No

Permission to modify individual analysis AFTER group analysis: ☐ Yes ☒ No

Enter deadline for individual input:

date (mm-dd-yy)  time (hh:ss)

Broadcasting of group results to group members who did NOT submit their analysis: ☒ Yes ☐ No

Permission for LATE group members to perform analysis AFTER deadline: ☐ Yes ☐ No

**Enter** **Cancel**

Figure 17. Information Exchange Screen

time, and thus the user should not be distracted by other display elements. This module consists of five simple boxes, along with two interactive screen interfaces. Additional dialogue, error, and help screens will be covered later in a miscellaneous screen interface section.

#### **1. Prioritization of Evaluation Criteria Screen**

Similar in function to either the Group Norm Identification screen (see page 33) and the Problem Definition screen (see page 27), this screen interface serves as the modules initial screen (see Figure 18). Two separate combo box lists allow the user to either type in the name of the problem and group norm or enable a drop down list of available choices. Both of these require selection to initiate the session and identify previously defined parameters to be utilized. In addition the user is asked to input his name. It is intended upon name input, that a password dialogue box overlay current screen and request the five character password which will be verified with the group norm selected. The password screen will be discussed in miscellaneous screen designs. If the password is correct, the user chooses via radio buttons, the method of ranking criteria. The Continue button accepts user choice and displays additional interfaces. The Cancel button returns the user to the Co-op Main screen.

## 2. Pairwise Comparison Screen

This screen interface is the input mechanism for the AHP process. The upper left portion of the screen represents up to a ten by ten positive reciprocal matrix (Ref. 1:p. 131). The user is queried about preference of criteria and requested to make a decision in the following frame box (see Figure 19). The default value of "no preference" returns a unit value of 1.0 to the corresponding two criterion in the matrix. If either "Yes" or "No" is selected, proper sequence is determined and displayed (see Figure 20). The user is then asked to determine his magnitude of preference either through direct entry in the shown text box or manipulation of a sliding bar. This process continues until all criteria in each level are evaluated as to preference. Once completed the Priority Vector is determined and displayed for user reference and the Modify, Stats, and Graph buttons will become available. The Modify button opens an interface that allows the user to change the current data. The Stats button displays a simple screen displaying matrix evaluation data. The Graph button allows the user to view graphically via a bar graph (not currently available) the same information as displayed in the Priority Vector. The Enter button accepts user input. The Cancel button returns the user to the Prioritization of Evaluation Criteria screen. The Help "?" button when incorporated will identify and clarify the various input and display mechanisms.

**Cooperative Multiple Criteria Group Decision Maker**

### Prioritization of Evaluation Criteria

Select problem for evaluation:

Select group norm:

Enter your name:

Select method for ranking criteria

☒ Pairwise Comparison

☐ Direct input of priorities

**Continue**

**Cancel**

Figure 18. Prioritization of Evaluation Criteria Screen

**Pairwise Comparison**

		1	2	3	4
1	Cost	1.00			
2	Maintenance		1.00		
3	Documentati			1.00	
4	Capability				1.00

Priority Vector

**Enter**

**Modify**

**State**

**Graph**

**Cancel**

Is Cost more important than Capability ?

Select one

☐ Yes

☐ No

☒ No Preference

**?**

Figure 19. Pairwise Comparison Screen



### **3. Modification Technique Screen**

This simple dialogue box allows the user to select via radio buttons a method of modifying the pairwise comparisonmatrix. The two choices available, again made via radio button selection, are to modify the matrix directly or to select specific criteria to update (see Figure 21). The Enter button accepts user input while the Cancel button returns the user to the Pairwise Comparison screen.

### **4. Criteria Modification Screen**

This simple dialogue box is made available if the user opts to select criteria to update on the Modification Technique screen. Two combo boxes with lists of available criteria are provided for user selection (see Figure 22). When the user selects the Enter button for data acceptance, these two criteria are displayed on the bottom of the Pairwise Comparison screen for evaluation in the same manner as originally input. The Cancel button returns the user to the Modification Technique screen without accepting any user input.

### **5. Statistical Evaluation Screen**

This screen, used for display of information only, provides statistical data relating to the pairwise matrix. In addition it informs the user through a short message of how consistent the matrix inputs were (see Figure 23). The OK button returns the user to the Pairwise Comparison screen.

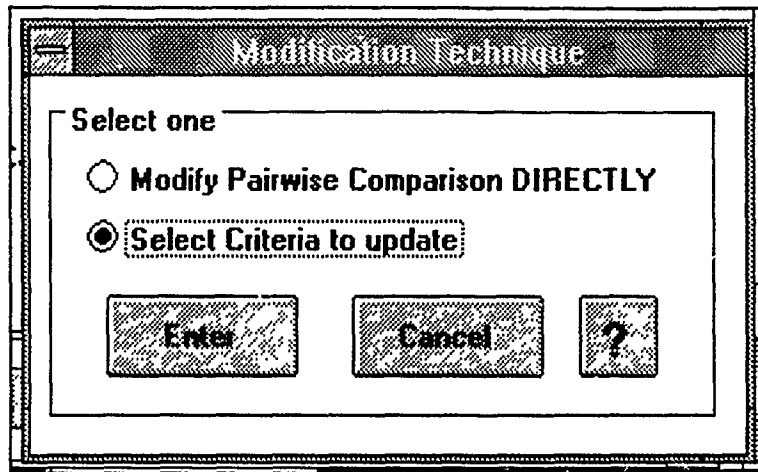


Figure 21. Modification Technique Screen

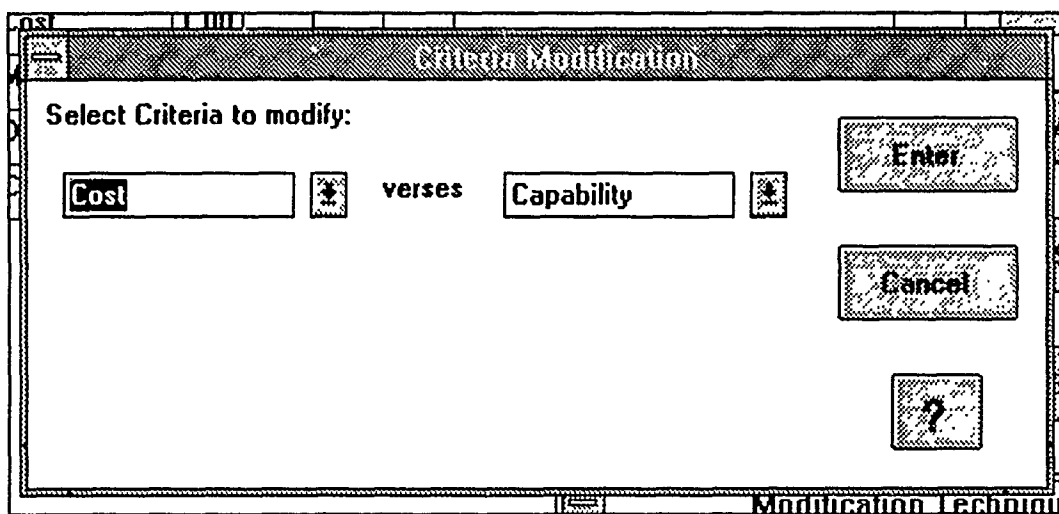


Figure 22. Criteria Modification Screen

## **6. Priority Vector Graph Screen**

This screen is intended again only to provide informative data in the form of a bar graph to the user and is not currently available. It is intended to be the same data as shown under the Priority Vector in the Pairwise Comparison screen only in the form of a bar graph for graphic interpretation for the user (see Figure 24). Criteria are displayed along the bottom of the display. The OK button returns the user to the Pairwise Comparison screen.

## **7. Direct Input of Criteria Weights Screen**

This screen interface, displayed as a result of selecting the second radio button on the Prioritization of Evaluation Criteria screen, allows the user to input directly his evaluation weighing of criteria (see Figure 25). Each level of criterion are intended to cycle through for his evaluation. Individual weights can be directly typed into the text box or manipulated via a sliding bar adjacent to the criteria. The Enter button accepts data and the next level of criteria (if applicable) are displayed until all criterion have been weighted. The Cancel button returns the user to the Prioritization of Evaluation Criteria screen.



**Statistical Evaluation**

LAMBA Max =

Consistency Index =

Randomized Index =

Consistency Ratio =

**NOTE: There is some statistical inconsistency in your evaluation.**

**OK**

Calc Program

Figure 23. Statistical Evaluation Screen

**Priority Vector Graph**

1.00  
0.80  
0.60  
0.40  
0.20  
0.00

Cost	Mainte	Docum	Capabil						
------	--------	-------	---------	--	--	--	--	--	--

**OK**

Figure 24. Priority Vector Graph Screen

Direct Input of Criteria Weights				
Criteria	Weights			
Cost				
Maintenance				
Documentation				
Capability				

Enter

Cancel

?

Figure 25. Direct Input of Criteria Weights Screen

## **E. ALTERNATIVES EVALUATION MODULE**

Building on the previous module of Criteria Prioritization, the Alternatives Evaluation module allows the user to prioritize the problem alternatives with respect to criterion and corresponds to the fourth process in the Co-oP model (see page 20). Using methods of Pairwise Comparison, ELECTRE, or direct evaluation, the user evaluates the alternatives as identified by the group. This module maintains the design considerations for screen interface as presented in the previous module, and thus utilizes many of the screen interfaces already presented, with minor modifications. This module consists of seven dialogue boxes and three interactive interfaces. Additional miscellaneous screens will be discussed in the final section.

### **1. Evaluation of Alternatives Screen**

This screen interface is of the same format and function as the Prioritization of Evaluation Criteria screen (see page 47). The only difference being the addition of four methods of ranking alternatives (see Figure 26). All functions and controls are intended to perform in the same manner.

### **2. Pairwise Comparison Screen**

This screen, with two modifications, performs the same function as the Pairwise Comparison screen as presented in section D (see page 47). Instead of comparing criteria, this interface allows the user to compare two alternatives with

**Evaluation of Alternatives**

Select problem for evaluation:

Select group name:

Enter your name:

Select method for ranking alternatives

- ☐ Pairwise Comparison
- ☐ Electre I
- ☐ Electre III
- ☐ Electre IV
- ☐ Promethee
- ☐ Direct input of alternatives

Figure 26. Evaluation of Alternatives Screen

respect to a single criterion. This screen adds an additional text line identifying that criterion (see Figure 27). The user evaluates the matrix as previously described, going through each criteria and looping through all three possible layers, if applicable, until all criteria have been used.

### **3. Modification Technique Screen**

This screen is the same interface as utilized in the Criteria Prioritization Module. As previously presented, it allows the user to either update the matrix directly or select individual alternatives and criteria to selectively modify (see section D.3.).

### **4. Alternative Modification Screen**

This screen interface performs the same functions as the Criteria Modification screen (see page 51). The only additional item is the inclusion of a combo box for the user to select the criteria the two alternatives are being compared against (see Figure 28).

### **5. Statistical Evaluation Screen**

This screen performs the same function as in the Criteria Prioritization Module (see page 51). Statistical data regarding the matrix is presented to the user if requested.

### **6. Priority Vector Graph Screen**

This screen interface with one modification performs the same function as the Priority Vector Graph Screen in the

Pairwise Comparison

		1	2	3	4
1	alternative 1	1.00			
2	alternative 2		1.00		
3	alternative 3			1.00	
4	alternative 4				1.00

Priority Vector

Enter

Modify

Save

Graph

Cancel

Evaluation of alternatives according to criterion -

Cost

Is alternative 1 more important than alternative 2 ?

Select one

☐ Yes  
☐ No  
☐ No Preference

?

Figure 27. Pairwise Comparison Screen

previous module (see page 51). The only additional information is the display of criteria in which the matrix is being utilized for comparison (see Figure 29). This interface will change in conjunction with the Pairwise Comparison criteria update.

#### **7. Evaluation of Alternatives Using Electre Screen**

This screen interface allows the user to compare decision alternatives based on well defined criteria preferences. The user is interactively queried to evaluate an alternative based on weights assigned to the criteria (see Figure 30). The user is looped through each alternative and is evaluated for each criterion. The user may enter values directly through a text box or manipulate the sliding box which changes the weighted values accordingly. The Enter button accepts current values and upon completion of all entries is hidden to display the complete Alternative Evaluation screen table. Cancel returns the user to the Evaluation of Alternatives screen. The Help button is intended to provide an overview text description of data entry.

#### **8. Alternative Evaluation Screen**

This screen interface receives inputs from the Evaluation of Alternatives Using Electre screen and displays them to the user in tabular format (see Figure 31). This table may be edited by the user directly. The Enter button displays the

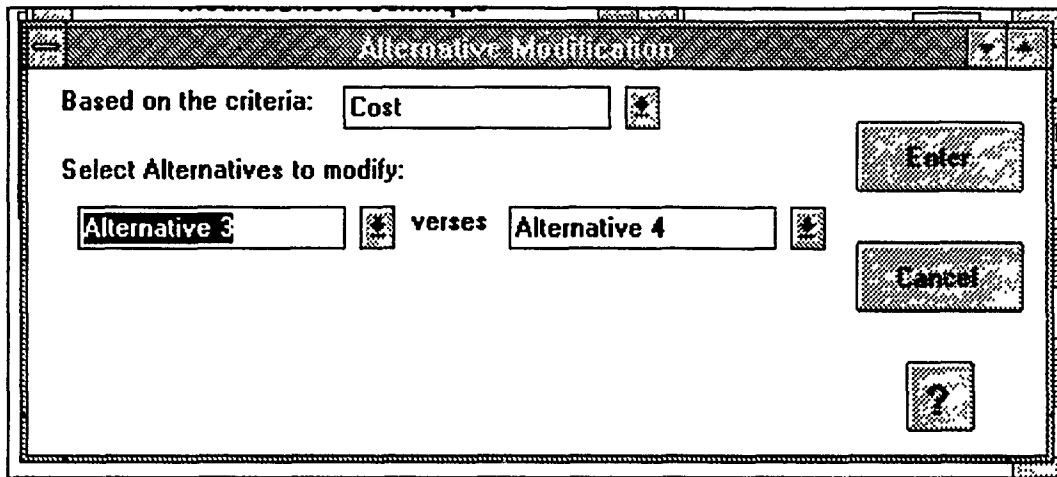


Figure 28. Alternative Modification Screen

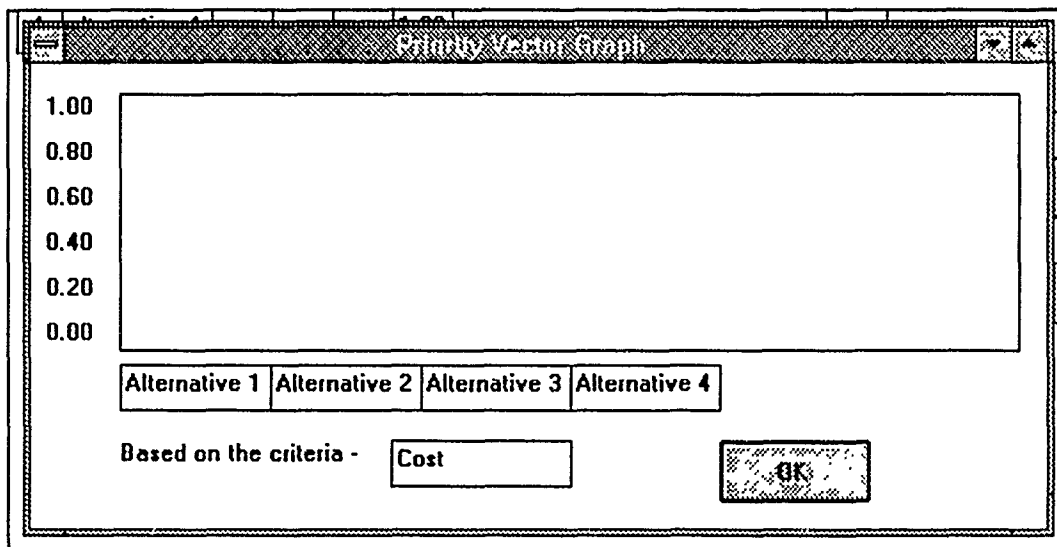


Figure 29. Priority Vector Graph Screen



Evaluation of Alternative using Electre

Evaluate the alternative **Alternative 1**

For criterion **Cost** any value between 0 and 13

0 11 value = 11

Enter

Cancel

?

Figure 30. Evaluation of Alternatives Using Electre Screen

Alternative Evaluation

Criteria

Alternatives	Cost	Maint	Docu	Capa
Alternative 1				
Alternative 2				
Alternative 3				
Alternative 4				

Enter

Cancel

?

Figure 31. Alternative Evaluation Screen

Matrix Selection screen and the Cancel button returns the user to the Evaluation of Alternative screen. The Help button is intended to display an overview of tabular functions.

#### **9. Direct Individual Evaluation Screen**

This interface allows the user to directly input alternative preferences based on criteria. Alternatives are displayed and the user either enters a weighted value directly via a text box next to the alternative or he manipulates the sliding bar corresponding to that alternative (see Figure 32). Data is entered until all criteria have been evaluated. A corresponding normalized priority vector is displayed for the users reference. The Enter button accepts data and enters the next criterion. Upon completion the user is returned to the Main Screen. The Cancel button returns the user to the Evaluation of Alternatives screen. The Help button is intended to display a summary of required inputs.

Microsoft Visual Basic 6.0  
Direct Input of Alternatives

Alternatives	Weights				Priority Vector
Alternative 1		★		★	
Alternative 2		★		★	
Alternative 3		★		★	
Alternative 4		★		★	

Enter

Cancel

?

Evaluation of alternatives according to criterion

Maintenance

Figure 32. Direct Individual Evaluation Screen

#### **F. DIRECT INDIVIDUAL EVALUATION MODULE**

This module may be substituted for the Criteria Prioritization and Alternatives Evaluation steps. If the user chooses to evaluate the alternatives directly without utilizing any of the available decision support models he has the option of choosing this step. The module itself only consists of one screen interface (see Figure 33). Up to 15 alternatives are presented and the user may enter his own weight factor, either directly in a text box or manipulating the associated sliding box. Normalized priority vectors are displayed for the users information. The Enter button accepts user input and the Cancel button returns the user to the Main screen. The Help button is provided to present a text outline of the current process.

#### **G. COMPUTATION OF GROUP DECISION MODULE**

This module consists of three screen displays, one simple input dialogue box and three output screens. The purpose of these screen interfaces is to display to the users the group problem results in various formats. Help formats will be discussed in general in the miscellaneous screen section.

##### **1. Computation of Group Results Screen**

This screen interface allows the user to select both the group problem and group norm from combo boxes (see Figure 34).

Direct Individual Evaluation				
Alternative	Weights			Priority Vector
Alternative 1				
Alternative 2				
Alternative 3				
Alternative 4				

Figure 33. Direct Individual Evaluation Screen

This input is used in determining group results. Additionally, the current user is asked to enter his name which will then prompt a password screen in order to verify the user is part of the group norm. If he is, he may then select various output formats using the appropriate radio button selection. The Enter button accepts user button selection and displays the corresponding screen. The Cancel button returns the user to the Main Co-oP screen.

## **2. Cardinal Rankings Screen**

This screen serves to display individual group members decision results to the group. This broadcasting of individual results is subject to restrictions as set forth in the group norm module. The current user selects via a combo box the member whose results he desires to see (see Figure 35). The alternatives along with corresponding weight factors are displayed as a list. The OK button returns the user to the Computation of Group Decision screen. The Cancel button returns the user to the Main Co-oP screen.

## **3. Ordinal Rankings Screen**

This screen interface functions similarly to the Cardinal Ranking screen. Users select individual group members to view the results of their rankings (see Figure 36). They may view several different group members alternative rankings by selecting different names from the combo box. Alternatives are ranked ordinally in list format. The OK button returns

Computation of Group Decision

Select problem for evaluation:

Select group Norm:

Enter your name:

Select ranking method

☐ Cardinal Rankings

☐ Ordinal Rankings

☐ Group Results

Continue

Cancel

Figure 34. Computation of Group Decision Screen

Cardinal Rankings

Select member:

Alternatives	Weight
alternative 1	<input type="text"/>
alternative 2	<input type="text"/>
alternative 3	<input type="text"/>
alternative 4	<input type="text"/>

Return

?

Figure 35. Cardinal Rankings Screen

the user to the Computation of Group Decision screen. The help button is intended to amplify information presented.

#### **4. Group Results Screen**

This screen interface allows the user to view the groups final results (see Figure 37). The alternatives are cardinally with four adjacent methods of ranking as follows:

- R1 : Maximum Additive Ranking
- R2 : Maximum Multiplicative Ranking
- R3 : Maximum Sum of Outranking Relations
- R4 : Minimum Sum of the Ranks

These methods would be readily available in the help text. The OK button returns the user to the Computation of Group Decision screen.

#### **H. IDENTIFY NEGOTIABLE ALTERNATIVES MODULE**

Although currently not available as an interface this modules intention is to help the group MCDM analyze and possibly resolve negotiation differences [Ref. 1:p. 62]. The Negotiable Alternative Identifier (NAI) is a proposed algorithm support decision makers analyze differences when techniques of aggregation of differences fail to find a unanimous decision. It is based on a three step expansion/contraction/intersection mechanism that attempts to optimize a solution.



Cooperative Multiple Criteria

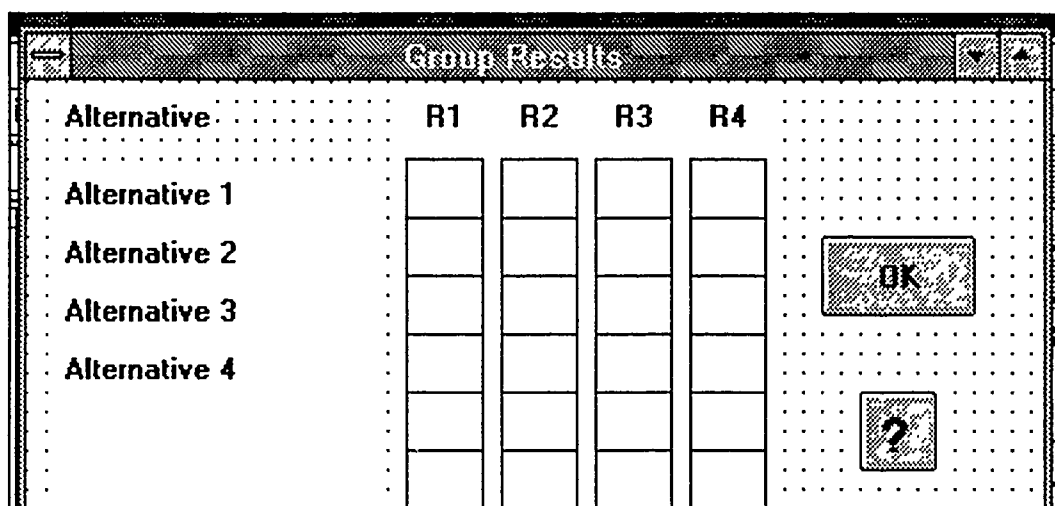
Ordinal Rankings

Select member: member 1

Ranking	Alternative
1	Alternative 3
2	Alternative 4
3	Alternative 2
4	Alternative 1

OK ?

Figure 36. Ordinal Rankings Screen



The image shows a software window titled "Group Results". It contains a table with four columns labeled "Alternative", "R1", "R2", "R3", and "R4". The "Alternative" column lists "Alternative 1", "Alternative 2", "Alternative 3", and "Alternative 4". Each of these rows has a corresponding empty cell in each of the "R1", "R2", "R3", and "R4" columns. To the right of the table, there are two buttons: an "OK" button and a button with a question mark "?".

Alternative	R1	R2	R3	R4
Alternative 1				
Alternative 2				
Alternative 3				
Alternative 4				

OK

?

Figure 37 Group Results Screen

## I. MISCELLANEOUS SCREEN INTERFACES

There are several additional screen layouts that may be utilized by this interface. The Help screen allows for either short informative text message or an extended list describing a screen function or model requirements (see Figure 38). Exiting the Help screen via an OK button returns you to the previously displayed screen. Help messages should be short and precise. If descriptive outlines are used, present them in a numbered step process. Error messages alert the user to possible problems with data input or application deficiency. As in the case of Help messages, they should be short and to the point with the OK button returning the user to the previously displayed screen (see Figure 39).

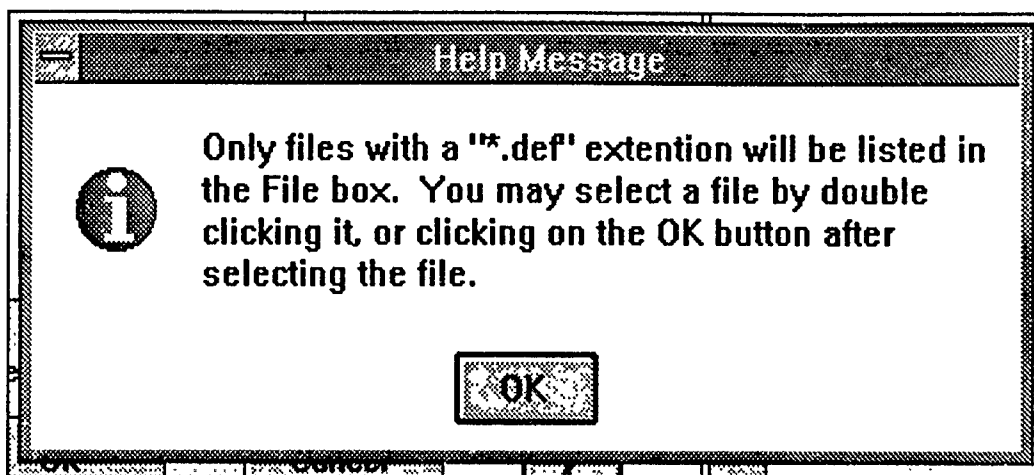


Figure 38. Help Screen

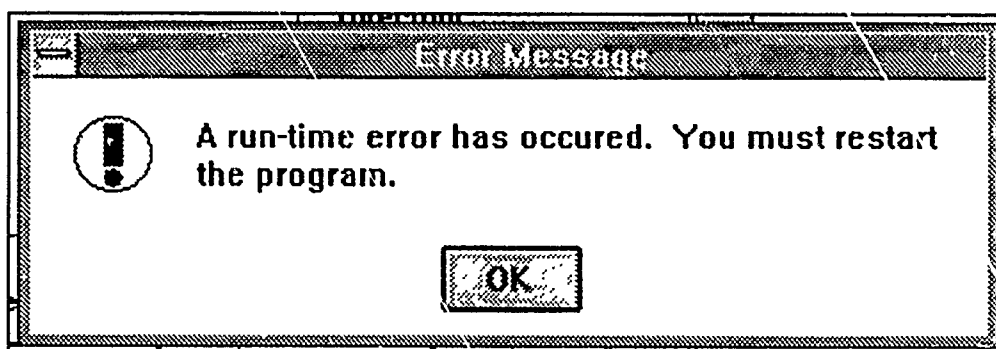


Figure 39. Error Screen

#### IV. SUMMARY AND RECOMMENDED FUTURE RESEARCH

##### A. SUMMARY

The intent of this research was to develop a graphical interface for Co-oP, a tool in support of group decisions. The proposed Graphical User Interface had to adapt to an already established educational tool and maintain the Co-oP applications framework and communication parameters in presenting GDSS models. Utilizing common GUI components and building on general principles of interface design, this GUI attempts to present a complex set of decision support tools that encourage user interest and participation through experimentation. With the user in mind, this prototype has mechanisms that allow him to control the sequence of events, screen designs that are consistent both in presentation and control devices, and focused screen designs which provide a clear conceptual picture of decision models presented. A major goal in this user interface design was to allow the user to be in command of the application and not let the application control user interaction.

##### B. RECOMMENDED FUTURE RESEARCH

At present this interface is a graphical screen shell, providing the visual interface to the Co-oP model. Areas that require continued research and implementation include:

- adding code to support screen implementation and provide data retrieval and error checking
- adding the AHP and ELECTRE algorithms
- conducting extensive user surveys through application test use and evaluation

This research design has provided the basis for an ideal Graphical User Interface. The design framework is in place but requires additional research and development in order to extend and explore the benefits the Co-op Multiple Criteria Group Decision Making model and expand on new topics it may uncover.

## LIST OF REFERENCES

1. Bui, Tung X., Co-oP: A Group Decision Support System for Cooperative Multiple Criteria Group Decision Making, Springer-Verlag, 1987.
2. Norman, Donald A. and Draper, Stephen W., User Centered System Design: New Perspectives on Human-Computer Interaction, Lawrence Erlbaum Associates, 1986.
3. Hayes, Frank and Baran, Nick, "A Guide to GUIs", BYTE, v.14, no. 7, pp.250-257, July 1989.
4. Gaines, Brian R. and Shaw, Mildred L. G., The Art of Computer Conversation, Prentice Hall Intl., 1984.
5. Mysers, Brad E., "Window Interfaces", IEEE Computer Graphics and Application, v. 8, no.5, pp.65-83.
6. IBM, Common user access: Advanced Interface Design Guide, File No. S370-40, International Business Machines Corp., 1989.
7. Shneiderman, Ben, Designing the User Interface: Strategies for Effective Human-Computer Interaction, Addison-Wesley Publishing Company, Inc., 1987.
8. Marcus, Aaron, "Designing Graphical User Interfaces: Part I", UnixWorld, v. 7, no. 8, pp.107-116, August 1990.
9. Shneiderman, Ben, Software Psychology: Human Factors in Computer and Information Systems, Winthrop Publishers, Inc., 1980.
10. Marcus, Aaron, "Designing Graphical User Interfaces: Part II", UnixWorld, v. 7, no. 9, pp.121-127, September 1990.
11. Marcus, Aaron, "Designing Graphical User Interfaces: Part III", UnixWorld, v. 7, no. 10, pp.135-138, October 1990.

# INITIAL DISTRIBUTION LIST

	No. Copies
1. Defense Technical Information Center Cameron Station Alexandria, VA 22304-6145	2
2. Library, Code 0142 Naval Postgraduate School Monterey, CA 93943-5002	2
3. Professor Tung X. Bui, Code 54Bd Naval Postgraduate School Monterey, CA 93943	1
4. Professor Balasubramaniam Ramesh, Code 54Ra Naval Postgraduate School Monterey, CA 93943	1
5. Computer Technology Curriculum Office, Code 37 Naval Postgraduate School Monterey, CA 93943	1
6. Lieutenant P.S. Posey 2400 Dogwood St. Fayetteville, AR 72703	2