2. OVERVIEW

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2.1 INTRODUCTION

This chapter is intended for readers having little or no familiarity with decision tables. The basic concepts and principles are defined so that the inexperienced reader will be able to appreciate the lucidity and flexibility of decision tables and understand the way in which decision tables are applied in the solution of procedural decision situations.

2.2 A STARTING POINT

Decision tables are used to describe and analyze problems that contain procedural decision situations that are characterized by one or more conditions the state of which determines the execution of a set of actions. Such situations may be too complex to be described simply with IF-THEN-ELSE and DO-CASE structures.

The process of describing a procedural decision situation by a decision table involves: (1) identifying all the conditions and actions associated with the situation, and (2) indicating which actions must be executed for various combinations of conditions. The decision table itself is simply a concise notational device for listing these conditions and actions as decision rules.

2.3 BASIC DEFINITIONS

2.3.1 Decision table format

A decision rule is the basic ingredient of the decision table. A rule describes a set of condition alternatives and a series of actions to be performed.

A decision table is a structure for describing a set of related decision rules. The basic parts of a decision table are shown in Figure 2-1. The upper left portion of the format is called the condition stub quadrant; it contains statements of the conditions. Similarly, the lower left portion is called the action stub quadrant; it contains statements of the actions. The condition entry and action entry quadrants appear in the upper right and lower right portions of the format, respectively. Each column in the entry portions (condition and action) forms a decision rule.

Decision tables are named by the content in the entry portion of the table:

> Limited-entry tables
> Extended-entry tables
> Mixed-entry tables

The decision table in Figure 2-1 is an example of a limited-entry table. This table contains only Y, N or - in the condition entry area and X or - in the action entry area.

```
...........................................................
:                          :      Decision Rules        :
:                          :    1   2   3   4   5   6    :
:..........................:...............................:
:      Condition Stub      :      Condition Entries     :
:                          :                            :
:      Condition 1         :    Y   Y   Y   N   N   N    :
:      Condition 2         :    Y   Y   N   Y   N   N    :
:      Condition 3         :    Y   N   -   -   Y   N    :
:..........................:...............................:
:       Action Stub        :       Action Entries       :
:                          :                            :
:      Action    1         :    X   -   X   X   X   X    :
:      Action    2         :    -   X   X   -   X   -    :
:      Action    3         :    X   -   -   X   X   -    :
:      Action    4         :    -   X   -   X   -   X    :
:..........................:...............................:
```

Where:

Y = Yes	= Condition is true
N = No	= Condition is false
- = Irrelevant	= Condition doesn't matter
- or blank	= Action is not performed
X	= Action is performed

Figure 2-1
Decision Table Format

In an extended-entry decision table, a portion of the condition [action] appears in the entry position of the table. An example of this extension is shown in Figure 2-2. A mixed-entry table is one which contains both limited and extended entries.

	Decision Rules				
	1	2	3	4	5
Condition Stub	Condition Entries				
Variable 1	<7	<7	=7	=7	>7
Variable 2	=1	Not = 1	–	–	–
Variable 3	=5	–	<5	>5	–
Action Stub	Action Entries				
Execute Procedure	105	71	47	36	81

Figure 2-2
Extended-entry Decision Table

2.3.2 Decision table form

The general form for a procedural decision situation is the "If Condition 1 and Conditon 2 and Condition 3 and ... then Action 1 and Action 2 and ...". Interpreting the first two decision rules in Figure 2-2 gives -- If Variable 1 is less than 7 and Variable 2 is equal to 1 and Variable 3 is equal to 5, then Execute Procedure 105, or If Variable 1 is less than 7 and Variable 2 is not equal to 1, then Execute Procedure 71.

2.4 EXAMPLES

Three examples are presented here. The first is a brief example to illustrate the basic decision table definitions discussed above, while the second the third are more extensive and show the way in which decision tables can be used to analyze as well as describe a procedural decision situation.

2.4.1 Example 1

Utility Rates: The local electric company charges residential customers a basic charge of $1.00 and a use charge of $0.03 per kilowatt hour (KWH) during the peak period (9 a.m. to 6 p.m.) and $0.01 per KWH from 6 p.m. till 9 a.m.; commercial customers are charged a base of $5.00 and a rate of $0.015 during the peak period and $0.005 per KWH other times; industrial customers pay a $10.00 base and a $0.009 rate.

Expressing the company's rate structure as a decision table requires the identification of conditions, actions and decision rules. The conditions are: type of customer and peak period. There are two actions: basic charge and use charge. Displaying these conditions and actions in decision table form results in Figure 2-3.

	Decision Rules				
	1	2	3	4	5
Customer is Peak Period?	Residential Y	Residential N	Commercial Y	Commercial N	Industrial −
Basic Charge	$1.00	$1.00	$5.00	$5.00	$10.00
Use Charge	$0.03	$0.01	$0.015	$0.005	$0.009

Figure 2-3
Electric Rates

Although this example is very simple, comparing the decision table of Figure 2-3 with the corresponding text, entitled "Utility Rates", immediately shows that decision tables can more clearly specific a decision situation.

2.4.2 <u>Example 2</u>

<u>Traffic Light:</u> There is a slightly intelligent traffic light at the
intersection of Otis St. and Lowell Avenue. There is much more traffic
on Lowell Avenue than there is on Otis Street, and so the light is
normally green for Lowell Avenue and normally red for Otis Street. But
there are two treadles on the roadway of Otis Street, for cars
approaching on Otis Street from either direction. If a car on Otis
Street drives up to the intersection, then ordinarily, and irrespective
of any traffic on Lowell Avenue, the light will turn green practically at
once for the Otis Street driver, and he will be able to go through the
intersection with a green light and hardly any delay. But that green
light for Otis Street lasts only long enough for four or five cards to
drive through the intersection, and then it once more turns red. Now if
another car approaches on Otis Street, that light stays red a long time,
irrespective of any cars on Lowell Avenue to use it. It lasts two
minutes, and then once more it will turn green for the Otis Street
driver.*

The procedural decision situation presented above is basically good, but
some clarification is necessary and additional information required to
improve the situation. Such words as "ordinarily", "practically", and
"hardly any delay" can be very misleading.

2.4.2.1 <u>Expansion</u>

Apparently the light is controlled by a timer whose behavior is not
described in the quotation. Also, the duration of the green light for
Otis Street is described as "only long enough for four or five cars".
The original quotation can be augmented to include the following
statements:

> The duration of a green light for Otis Street is 15 seconds.

> There is a minimum duration of 2 minutes for a green light on
> Lowell Avenue.

> The timer operates in intervals of 0.01 seconds.

> Every hundredth of a second the status of the light, of the treadle,
> and of the time are interrogated. If this interrogation results in
> a change in the status of the light, the timer is reset to zero;
> otherwise, it is incremented by 0.01.

---

* Example from Edmund C. Berkely

2.4.2.2. Solution

A decision table describing the behavior of the light at Otis Street and Lowell Avenue is shown in Figure 2-4.

	1	2	3	4	5	6
Is Lowell Avenue Light Green?	Y	Y	Y	Y	N	N
Is Otis Street Treadle OFF?	Y	Y	N	N	-	-
Is Time?	$\leq$120	>120	>120	$\leq$120	>15	$\leq$15
Change Light Direction	-	-	X	-	X	-
Set Timer to zero	-	-	X	-	X	-
Set Treadle OFF	-	-	-	-	X	-
Increment Timer by 0.01 sec	X	-	-	X	-	X
Repeat Table Logic	X	X	X	X	X	X

Figure 2-4
Traffic Light

2.4.3 Example 3

This example illustrates the way in which decision tables can be used to resolve ambiguities and identify incomplete problem descriptions.

Examination Regulations: The student who was not successful in the first examination session of the academic year belongs to one of the following categories: failed, rejected, equivalent to rejected. If a student failed the first examination, he is admitted to the second examination session of the academic year. A student is considered "rejected" only because of cheating during the exams. A rejected student cannot participate in the second examination session. A student is considered "equivalent to rejected" if he does not participate in the first examination session (unless there is a serious reason for missing the exam). A student who is "equivalent to rejected" may participate in the second examination only by special permission of his department.

2.4.3.1 Expansion

These regulations are described by the decision table in Figure 2-5.

	Decision Rules															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Student successful in first exam	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Student caught cheating	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	N	N	N
Student took first exam	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N
Student has serious reason for not taking first exam	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Failed	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rejected	–	–	–	–	–	–	–	–	X	X	X	X	–	–	–	–
Equivalent to Rejected	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	X

Figure 2-5
Examination Regulations

The decision table in Figure 2-5 exactly records the verbal statement of the examination regulations. Nothing has been added or deleted. Notice the following aspects of the regulations:

(1) No actions are indicated for the first eight rules. The regulations only seem to be concerned with students who were not successful in the first examination session.

(2) The "failed" action is never executed. The regulations do not explicitly state the rules under which a student fails.

2.3.4.2 Solution

In this section, various properties of decision tables (which are explained in Chapters 3 and 5) are used to analyze the stated requirements and improve the problem description.

Completeness

If the decision table in Figure 2-5 is complete, then there are no rules that are missing. An alternate way of saying this is that actions are given for all possible circumstances of the conditions. The decision table in Figure 2-5 is, in fact, a complete decision table. Every possible combination of conditions is stated and no rules are redundant.

Consistency

Given a complete decision table, the first step is to determine whether or not it is consistent. This involves identifying whether or not certain combinations of conditions are "impossible" in terms of the problem. The second step is to resolve missing actions for "possible" rules.

Referring to the decision table in Figure 2-5, it is clear that Rules 3, 4, 7, and 8 are impossible because they refer to a student who was successful on the first exam and did not take the first exam. Similarly, Rules 11 and 12 are impossible because they refer to a student who was caught cheating and did not take the first exam. Rule 12 as originally stated contains a second error: the student is considered to be both "rejected" and "equivalent to rejected."

At this point, the remaining rules (1, 2, 5, 6, 13, 14, 15) would be returned to the problem poser (a faculty committee) for further definition. For the purpose of this example, suppose the response is as follows:

> Rules 1 and 2: Refer to a faculty committee to choose between "pass" and "reject" depending on the degree of cheating involved.
>
> Rules 5 and 6: Student is considered "passed."
>
> Rules 13, 14, 15: Student is considered "failed."

The decision table in Figure 2-6 contains the first revision of the examination policy. Notice that two new actions (passed and impossible) have been added.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Successful?	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Cheating?	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	N	N	N
Took first exam?	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N
Serious reason for missing first exam?	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Impossible	–	–	X	X	–	–	X	X	–	–	X	X	–	–	–	–
Passed	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–
Failed	–	–	–	–	–	–	–	–	–	–	–	–	X	X	X	X	–
Rejected	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	–
Equivalent to Rejected	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X
Refer to committee	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Figure 2-6
Revised Examination Regulations

Finally, it is necessary to consolidate decision rules where possible. The result of rule consolidation is a decision table that can be more easily read by people. This result is shown in Figure 2-7. The rule numbers refer to the rules in the decision table in Figure 2-6.

	(Original Rule Numbers)							
	1,2	3,4,7,8	5,6	9,10	11,12	13,1		16
Successful?	Y	Y	Y	N	N	N	N	N
Cheating?	Y	–	N	Y	Y	N	N	N
Took first exam?	Y	N	Y	Y	N	Y	N	N
Serious reason for missing first exam?	–	–	–	–	–	–	Y	N
Impossible	–	X	–	–	X	–	–	–
Passed	–	–	X	–	–	–	–	–
Failed	–	–	–	–	–	X	X	–
Rejected	–	–	–	X	–	–	–	–
Equivalent to Rejected	–	–	–	–	–	–	–	X
Refer to committee	X	–	–	–	–	–	–	–

Figure 2-7
Condensed Examination Regulations

2.5 COMMENTARY

Based on the foregoing examples, it should be clear that decision tables are a concise, accurate, and flexible format to represent procedural decision situations. The material in Chapter 5 (Development Methodology) describes the various ways that decision tables can be used in systems development. Such situations are partitioned by the desired end result: either a computer program or a set of decision procedures to be manually executed. For the former case, various computer and translator-related issues become important; these are discussed in Chapter 4 (Conversion Algorithms). Generally speaking, if a decision table is to be "executed" manually, it can have a less restrictive (more human-oriented) format, limited only by the person who will "execute" the decision table.

Perhaps the greatest advantage of using decision tables in designing systems is that they introduce a discipline. The designer must begin with a notion of how the system will work. However, because of the exhaustive combinatorial power of decision tables and their inherent logical testing possibilities, system failures will be brought to the designer's attention during the design stage rather than in the middle of a crucial 'live' situation. Because of their simple syntactic structure, decision tables can be read and stored very easily by a computer. They can therefore form the basis for a machine-readable representation of the design.

Decision tables have a simple and human-oriented structure. Therefore, they are an ideal medium for documentation and communication. Indeed, decision tables can be manipulated and understood very easily by the user. This gives to the user some control over systems development and will increase the user's confidence in the system.