The Table of Distribution and Allowances (TDA) System Analyzer

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Abstract

TDA documents determine the personnel strengths for each Army installation. They reflect the number of people required to accomplish a certain mission by various characteristics. US Army Training and Doctrine Command (TRADOC) analysts continuously scrutinize these documents to ensure that they comply with provided guidance. Part of this guidance has been used to develop a set of manual rules. Analysts apply these rules to the TDA to: (1) eliminate positions; (2) downgrade positions; or (3) reduce position strength. However, this process is very time consuming. In addition, human involvement introduces inconsistencies and errors that are difficult to detect later.

This paper explains how I represented these rules using the 'C' Language Production System (CLIPS) to develop an expert system that is applied consistently and comprehensively for all TRADOC installations. The TDA System Analyzer reduces the review process from about five days to just twenty minutes; giving the user more time to analyze the results and thereby make better decisions. Furthermore, the user is assured that the rules are applied uniformly to every TDA document.

This paper also explains the integration of the TDA System Analyzer into TRADOC's On-Line TDA System. Providing the analyst an extra utility module that can be accessed from a familiar environment.

1. Introduction

Installations rarely receive the exact number of soldiers that they request. Therefore, distributing scarce personnel resources is a problem. It will become more acute as the Army reduces its current 764,000 active-duty force by 184,000 soldiers in the next four years. TRADOC, being the Army's major headquarters for training, is responsible for distributing its share of personnel resources to its subordinate installations.

This process is dynamic and complex. It involves manually reviewing large TDA documents (some having more than 10,000 records) for conflicts with policy, inaccurate grading structures, and incorrect number of soldiers filling a position. The manpower analyst must be familiar with a variety of current and new force structures, unit modernization options, and manpower relationships between units and activities. At a high level, the analyst must be able to formulate plans to distribute new personnel resources and redistribute existing personnel. At a low level, the analyst must track very detailed information to determine the implications on individual units while abiding with current policy.

The sheer size of the TDA documents often forces the analyst to spend an inordinate amount of time reviewing the documents for inconsistencies rather than analyzing them for policy compliance and distribution requirements. In addition, the review process is mundane and subject to error. These errors can adversely affect later analysis.

The purpose of the TDA System Analyzer is to conduct the initial review of the TDA document for the analyst. It scrubs each document using a dynamic rule set written in CLIPS and highlights potential inconsistencies. The analyst concentrates only on these discrepancies; devoting more time to high level analysis.

The TDA System Analyzer executes on a Zenith 248 Personal Computer (PC) with 640 kilobytes of internal memory and 20 megabytes of external hard disk space. The system is an external utility module within TRADOCs On-Line TDA System. The On-Line TDA System is a dBase III™ program that brings TDA databases residing on mainframes to manpower analysts using PCs.

2. The Rules

In 1988, the Commanding General of TRADOC, General Maxwell Thurman, initiated development of a rule set to quantify the discrepancies an analyst should detect while reviewing a TDA document. He intended that an expert system use these rules to relieve the analyst of the initial review process.

The set contains two types of rules: (1) those defining exact discrepancies in the document; and (2) those

showing grading structures by position. The first type describes the conditions within the TDA document the system searches. For example, an officer cannot work for another officer of the same grade. If the situation exists where a Captain works for another Captain, the system detects this and reports a problem to the analyst.

The second type specifies the grade or rank for a position at a certain level. For instance, a rule might state that a Company Commander be a Captain. In this example, the position is Commander, the level is Company and the grade is Captain. If the system detects a Major as a Company Commander, a discrepancy is sent to the analyst. Appendix A provides a complete listing of the rules.

3. System Components and Design Methodology

I used a phased control methodology as the basic design for the TDA System Analyzer. Phase control facts are asserted and retracted depending on the current state of processing. Figure 1 shows the sequence of phases.

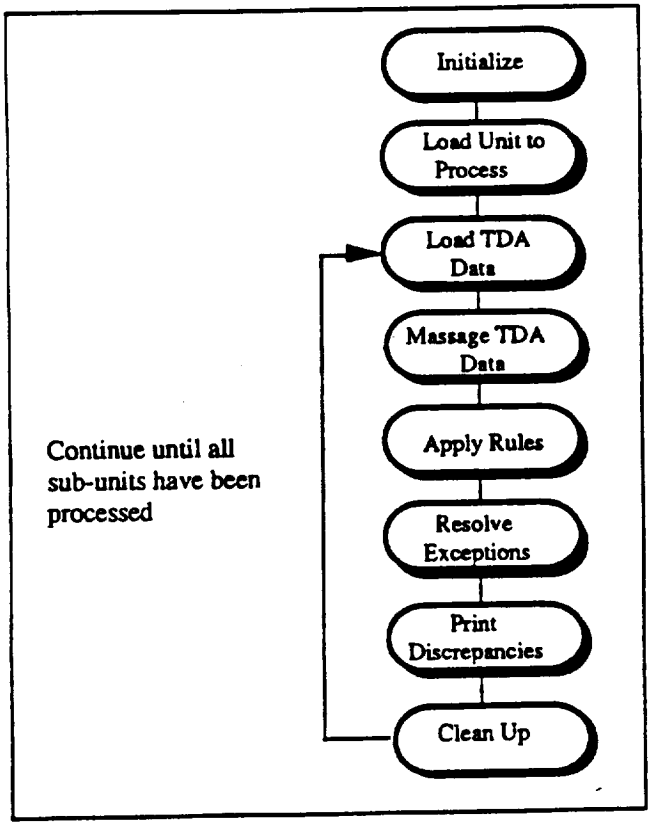

Figure 1. Sequence of Phases

3.1 Initialize

My recompiled version of CLIPS receives three parameters – the file name of the CLIPS rule set, the file name of a dBase III™ database containing position grading data (this will be discussed later), and the name of a TDA document. The system uses the first parameter to load the rule set. It uses the next two parameters to assert two relations. These are **(database "dBase III™ file name")** and **(process "file name of TDA document")**. The first indicates the database that queries will be made to. The second fact tells the system which TDA document to open for processing.

3.2 Load Unit to Process

This phase determines the type of installation that will be analyzed. Different TRADOC installations require different types of analysis as reflected in the corresponding type 2 rules. For instance, the system processes a Service School differently than a Brigade.

A dBase III™ database captures information about the processing requirements for the different installations. The information stored in this database is the triplet (level, position, grade). Type 2 rules use this triplet to detect discrepancies. This data can be thought of as system parameters that can be deleted, modified, or added by the user.

When the system determines the installation type, it queries the database for just the data it needs to review that particular installation. An external function, **ssql** (Small Structured Query Language), executes this. This function provides direct access to dBase III™ data files using a subset of the Structured Query Language (SQL). For instance, the following rule uses **ssql** to query the **Grading-Info** database for Service School data.

```
(defrule get-level-service-school
  (phase load-UIC-to-process)
  (service-schools $?service-schools)
      ;;; Service School IDs
  (UIC ?uic&:(> (member ?uic $?service-schools)))
      ;;; is this a service school
=>
  (ssql "grading-data"
        "select * from Grading-Info where
              level = service-school"))
```

Figure 2. Rule Calling ssql

ssql asserts relations of the following type into the knowledge base: **(grading-data "level" "position" "grade")**. These facts represent the permissible grading structures for this installation type.

3.3 Load TDA Data

TDA documents can contain more than 10,000 records. It is impractical to reason about all 10,000 records concurrently. Therefore, the system loads records in small segments based on sub-unit designation and asserts any necessary relations to do reasoning between the different sub-units.

3.4 Massage TDA Data

Several rules require cumulative figures (total number of officers, total number of personnel in this sub-unit, total number of officers by speciality) to determine possible discrepancies. The TDA document does not store this information explicitly. This phase gathers this information and asserts it in the knowledge base for use by the rules in the next phase.

3.5 Apply Rules

During this phase, the system applies the two rule types to detect discrepancies. Initially, I coded a separate rule for each listed at Appendix A. However, the commonality between type 2 rules permitted me to replace these rules with just one. This single rule detects discrepancies by first matching on the **grading-data** relation and then matching on any TDA records that have the same level and position but different grade. (See Figure 3)

```
(defrule grading-rule
  (phase actions)
  (grading-data ?level ?position ?grade)
  (TDA
    (LINE ?line)
    (PARA ?para)
    (SUB-PARA ?sub-para)
    (GRADE ?TDAgrade&~?grade)
    (DESCRIPTION ?desc&:(&&
      (>= (str-index ?level ?desc) 1)
      (>= (str-index ?position ?desc) 1))))
=>
  (assert
    (discrepancy ?para ?sub-para ?line
                 ?TDAgrade ?desc ?position ?level)))
```

Figure 3. Example of a Type 2 Rule

3.6 Resolve Exceptions

It is possible with type 2 rules to have different grades for the same position and level. For example, a Major or Captain (grade) may be an Action Officer (position) at the Service School level. If one of these cases occurs in the TDA document, the system reports a discrepancy. Yet, either grade is satisfactory for this position. This phase eliminates these discrepancies before reporting them to the analyst. The TDA System Analyzer accomplishes this by first matching on the discrepancy and then searching the knowledge base for a **grading-data** fact that matches the level, position, and grade of the discrepancy. If such a fact exists, the discrepancy is removed. Other exceptions are handled during this phase, but most are the type mentioned above.

3.7 Print Discrepancies

The knowledge base contains only valid discrepancies at this point. The system writes these to an output file that can be later reviewed and manipulated by the analyst.

3.8 Clean Up

During the data massage phase, the system asserted a number of relations containing cumulative figures. This information is only valid while processing the current sub-unit. This data must be removed before the TDA System Analyzer can review the next sub-unit. This phase retracts these facts.

The program loops through phases three to eight until all sub-units of the TDA document are processed. The system then closes the TDA document file and discrepancy output file.

4. Performing a TDA Document Review

We integrated the TDA System Analyzer in the On-Line TDA System as a utility module. The analyst uses the On-Line TDA System daily and is comfortable with its structure and user interface. These characteristics make using the TDA System Analyzer easier.

The analyst first calls the On-Line TDA System's utility module. He then chooses the TDA System Analyzer. At this point, the user can elect to process the document with the current parameters or he can access the dBase III™ database to change them. The ability to change system parameters so readily permits him to alter dynamically the way the system will review a document. In addition, the analyst can do "what-if" exercises. For example, he may

wonder what discrepancies will be found if he changes Battalion Commanders at the Service School level from Lieutenant Colonels to Majors. The analyst does this easily using the appropriate dBase III™ commands.

When the analyst is satisfied with the system parameters, he chooses the specific TDA document to process and tells the system to execute. A review of 10,000 records requires approximately 25 minutes. This performance compares with a typical 40 man-hour analysis – an improvement of almost 100:1. In addition, the review is complete and consistent. After execution, the analyst can browse the discrepancy output on-line or print it to hard-copy for future reference.

The On-Line TDA System also supports batch processing of the TDA System Analyzer. Analyses can be run during non-duty hours on many TDA documents and/or on the same document with different parameter settings.

5. Summary

The TDA System Analyzer represents an innovative way of analyzing TDA documents. It gives the manpower analyst the power to change dynamically the way a document will be processed, but isolates him from the mundane task of actually doing the review. He can focus more on issues, policy, and personnel distribution problems.

The power and flexibility of the CLIPS' environment supported the rapid development of a system that could be iteratively refined. I was able to implement quickly improvements and changes. The power of this environment permitted me to develop a complete system with extensions to the basic functionality of CLIPS in less than three months.

Appendix A
TDA System Analyzer Rules

I. Type 1 Rules

a. Officers will not work for other officers of the same grade.

b. There will be no deputies or assistants except at general officer commanded installations.

c. All ROTC military schools (e.g., Citadel, Norwich) will be allowed one Major (MAJ) as Commandant of Cadets.

d. Support an additional ROTC Captain (CPT) position at historically black colleges.

e. No more than 30% of total officers will be field grade in any element at the Service School level.

f. Support only 75% of CAS^3 instructors in grade of Lieutenant Colonel (LTC).

g. Where there is more than one position in a single job title/specialty, indicate that 50% of these may be downgraded.

h. Support only one LTC in the office of a TRADOC System Manager.

II. Type 2 Rules - indicate the appropriate grade for a particular position and level.

LEVEL	POSITION	GRADE
Installation	Commander	Major General
Installation	Commander	Brigadier General
Installation	Deputy Commander	Brigadier General
Installation	Deputy Commander	Colonel (COL)
Installation	Chief of Staff	COL
Installation	Resource Manager Director	LTC
Installation	Engineering & Housing Director	LTC
Installation	Inspector General	LTC
Installation	Airfield Commander	MAJ
Installation	S-1	(Null)[1]
Installation	S-2	(Null)
Installation	S-3	(Null)
Installation	S-4	(Null)

[1] A null value indicates that this position is not valid at any grade for this level.

II. Type 2 Rules (continued)

LEVEL	POSITION	GRADE
Army Training Center (ATC)	Commander	Brigadier General
ATC	Deputy Commander	(Null)
ATC	Chief of Staff	(Null)
ATC	Resource Manager Director	(Null)
ATC	Engineering & Housing Director	(Null)
ATC	Inspector General	(Null)
ATC	Airfield Commander	(Null)
ATC	S-1	CPT
ATC	S-2	MAJ
ATC	S-3	MAJ
ATC	S-4	CPT
Brigade	Commander	COL
Brigade	Deputy Commander	(Null)
Brigade	Executive Officer	LTC
Brigade	S-1	CPT
Brigade	S-2	CPT
Brigade	S-3	CPT
Brigade	S-4	CPT
Battalion	Commander	COL
Battalion	Deputy Commander	(Null)
Battalion	Executive Officer	MAJ
Battalion	S-1	CPT
Battalion	S-2	CPT
Battalion	S-3	CPT
Battalion	S-4	(Null)
Service School	Liaison Officer	MAJ
Service School	Liaison Officer	CPT
Service School	Action Officer	MAJ
Service School	Action Officer	CPT
Service School	System Manager	COL
Service School	Threat Manager	MAJ
Service School	Communication Skill Officer	MAJ
Service School	Proponency Officer Chief	LTC
Service School	Department Director	COL
Service School	Department Director	LTC
ROTC	Professor of Military Science	LTC
ROTC	Enrollment Team Officer	CPT

[2] LTC will be a Department Director if there are less than 65 people in the department.