METAL

Mechanical Translation and Analysis of Languages

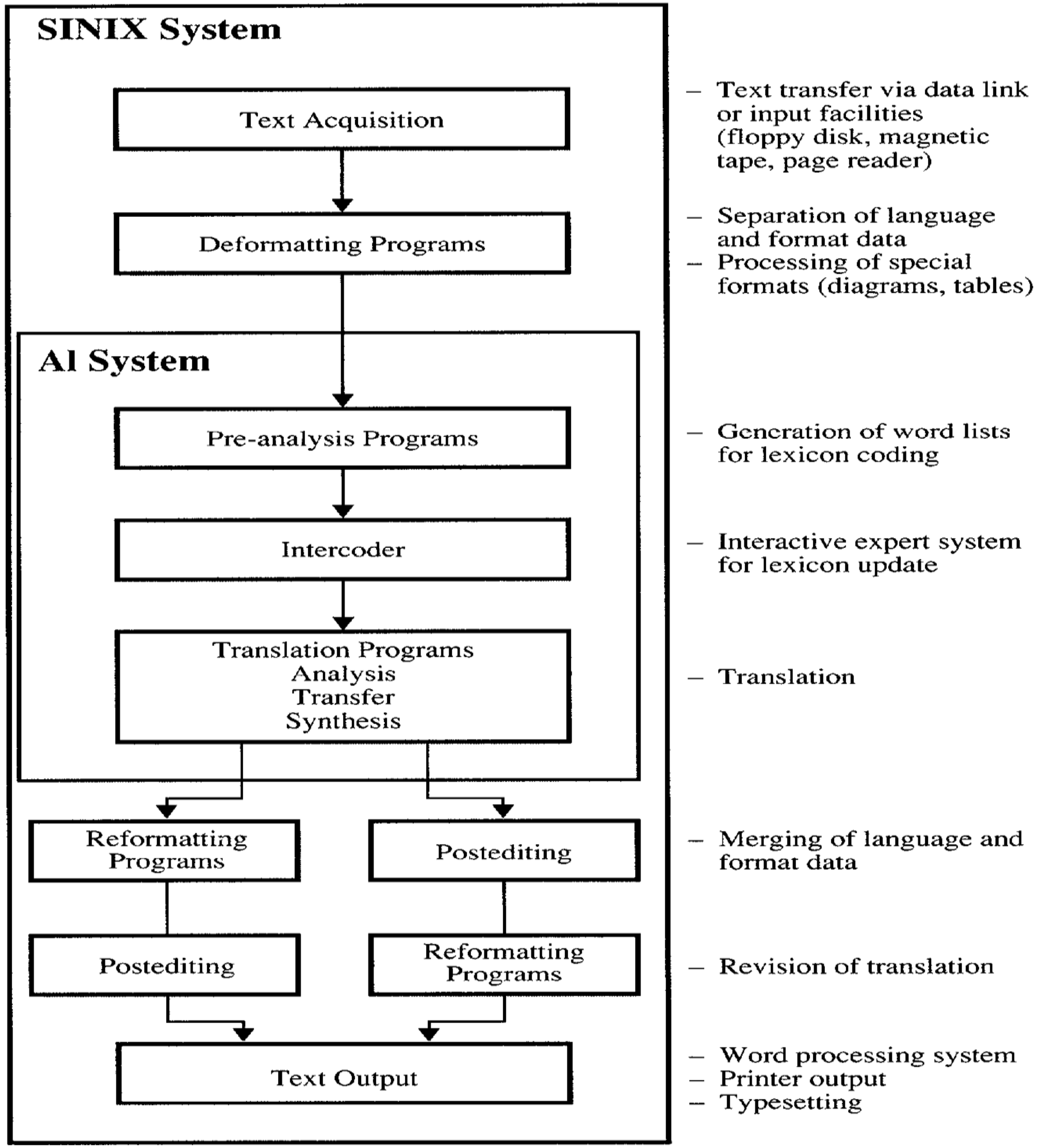
- Machine translation research at the Linguistics Research Center, Texas began in 1970 with Rolf A. Stachowitz as principal researcher. Research funding came from the USAF Rome Air Development Center and other U.S. government agencies for the Metal system.
- Siemens AG began funding system in 1979.
- For market testing, first operational version of the system transmitted in 1985.

- fully-automatic high quality rule based machine translation system
- attempted Interlingua experiments, but it essentially adopted a transfer approach.
- besides the German to English system which has been operational for quite some time, German to Spanish, Dutch to French, English to German have been released

System structure

- The linguistic component of Metal is developed in Lisp and the text processing component are written in C.
- The hardware package of system consist of several translator workstations and a dedicated Lisp machine running as a server in the background. This server linked via Ethernet to a multi-user translator workstation. From these terminals, translation jobs are started and all the tasks are handled.
- The Metal system was built in a highly modular way. There is a language independent linguistic processor that includes language-specific modules for analysis, transfer and synthesis.

Translation Process



Lexical Analysis

- Function words (prepositions, conjunctions, pronouns, determiners etc.), general words, technical words, prefixes, infixes, inflectional endings, punctuation, symbols constitutes the lexical database for German and English entries.
- The Metal System contains lexicons which are either monolingual or bilingual. In analysis or generation, system used monolingual lexical entries that includes the canonical form.
- The bilingual lexicons reveal correspondence between source and target language.

German monolingual lexicons

```
(gehen          CAT(VST)
      ALO   (gang)
      PLC   (NF NI)
      TAG   (ALL)
      SNS   (1)
      PX    (NIL)
      ARGS  (#PP #NIL)
      TT    (I)
      AX    (sein)
      CL    (PP-GEEN)
)

(gehen          CAT(VST)
      ALO   (ging)
      PLC   (WI)
      TAG   (ALL)
      SNS   (2)
      PX    (NIL)
      ARGS  (#PP #NIL)
      TT    (I)
      AX    (sein)
      CL    (PAI-3 PAS-3)
)
(gehen          CAT(VST)
      ALO   (geh)
      PLC   (WI)
      TAG   (ALL)
      SNS   (3)
      PX    (NIL)
      ARGS  (#PP #NIL)
      TT    (I)
      AX    (sein)
      CL    (IMP-1 INF-EN PRI-1 PRS-1)
)
```

- For the English monolingual lexicons, the principals and particular lexical entries are the identical with the German.

- (VST): the dictionary form *gehen* is a verb stem
- (ALOs): stem forms or allomorphs of *gehen; gang*, *ging* and *geh*
- (PLC (WI)): *ging* and *geh* which ALOs of *gehen* must be preceded by a blank. (PLC (NF NI)): non-blank characters, the past participle marker and an ending, must precede and follow the ALO *gang*.
- (TAG (ALL)): *gehen* is a general term
- (SNS): a unique system-assigned number for each entry
- (PX (NIL)): *gehen* takes no prefix as canonical form
- (ARGS): *gehen* appears either with no non-subject or with a single prepositional phrase argument (PP)
- (TT (I)): transitivity type feature showed that *gehen* is intransitive
- (AX (sein): auxiliary of *gehen* is *sein*
- (CL): inflectional classes defines various allomorphs, such as PP-GEEN show that *gang* as allomorphs of *gehen* takes a *ge-* participle and an *–en* ending.

Bilingual lexicons

- There is an example for the German verb *gehen* with transfer entry;

```
(go    (gehen) VST (CAT VST)(PX NIL)(PF FIN INF PAPL))
(outgo      (gehen) VST (CAT VST)(PX NIL)(PF PRPL))
```

- According to first entry, *gehen* is equivalent to the English *go* word under some certain conditions such as the German stem doesn’t have a prefix (PX), also its predicate form (PF) is infinitival (INF), finite (FIN) or past participial (PAPL). The second entry shows that gehen is outgo while it is a present participle (PRPL) and has no prefix.

Grammar Rule composition

- Words, phrases, clauses are built by grammar rules which consist of a number of parts.
- VB -> VST V-FLEX rule:

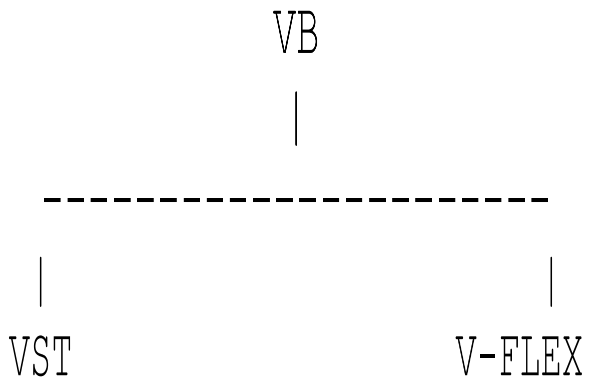
First line that defines which the rule applies, a verb (VB) may include the verb stem (VST) and the verb ending (V-FLEX).

Third line defines the limit of this sample rule, so the verb stem must be preceded by a blank (REQ WI). On the contrary, the verb ending mustn't be preceded by a blank (NRQ WI). TEST part shows the validity and constraints of the grammar rule.

```
VB        VST          V-FLEX
0         1            2
--        (REQ WI)     (NRQ WI)
TEST      (INT 1 CL 2 CL)
          (OR (NOT (INT 2 PF PAPL))
               (INT 1 CL PP-T PP-ET PP-EN PP-N))
          (OR (INT 2 PF PAPL INF)
          (RET 2 WF))
CONSTR    (CPX 1 ALO CL)
          (CPY 2 PS NU TN MD PF WF)
          (ADD WI)
          (AND (INT 2 PS 3)
               (INT 2 NU SG)
               (PRF 2))
          (*TAG ALL)
TRANSF    (XFM VB)
```

- The appropriate syntactic tree is constituted using right hand elements as the children of left hand elements by the CONSTR part of the rule, after tests are succeeded.

- CONSTR builds the syntactic tree for our sample rule, with copying ((CPX), (CPY)) and adding ((ADD), (PRF)) crucial information to the new node. (TRANSF) Transfer applies a transformation named (VB).

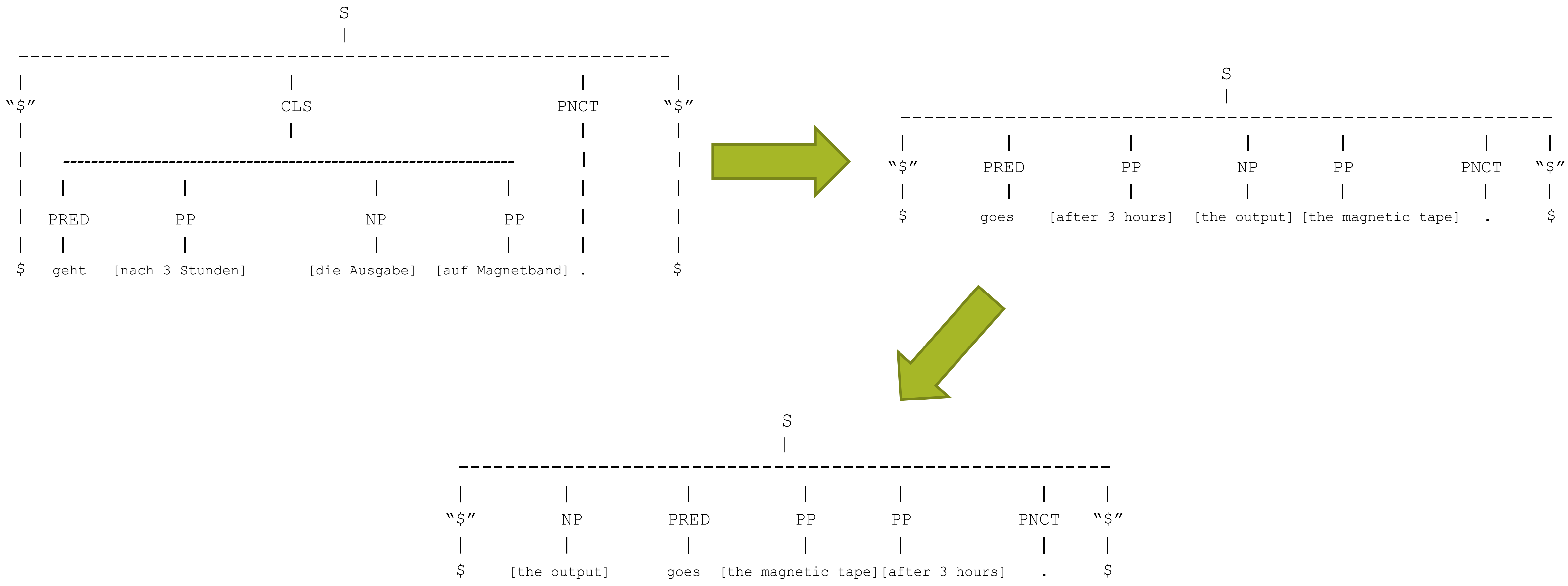


Grammar Rule operation: Analysis

```
(gehen             CAT(VST)
      ALO    (geh)
      PLC    (NF NI)
      TAG    (ALL)
      SNS    (3)
      PX     (NIL)
      ARGS   (#PP #NIL)
      TT     (I)
      AX     (sein)
      CL     (IMP-1 INF-EN PRI-1 PRS-1)
)
(tl                CAT(V-FLEX)
      ALO    (t)
      PLC    (NI)
      SNS    (7)
      CL     (PRI-1 PRI-2 PRI-4 PRI-5 PRI-6 PRI-16)
      NU     (PL)
      PS     (2)
      MD     (IND)
      PF     (FIN)
      TN     (PR)
)
(tl                CAT(V-FLEX)
      ALO    (T)
      PLC    (NI)
      SNS    (8)
      CL     (PRI-1 PRI-2 PRI-4 PRI-5 PRI-11 PRI-13 PRI-14)
      NU     (SG)
      PS     (3)
      MD     (IND)
      PF     (FIN)
      TN     (PR)
)
```

```
                  VB
                  |
    -------------------------
    |                       |
   VST                   V-FLEX
    |                       |
   geh                      t
```

Rule operation: Transfer



nach 3 stunden geht die ausgabe auf magnetband → *the output goes to magnetic type after 3 hours.*

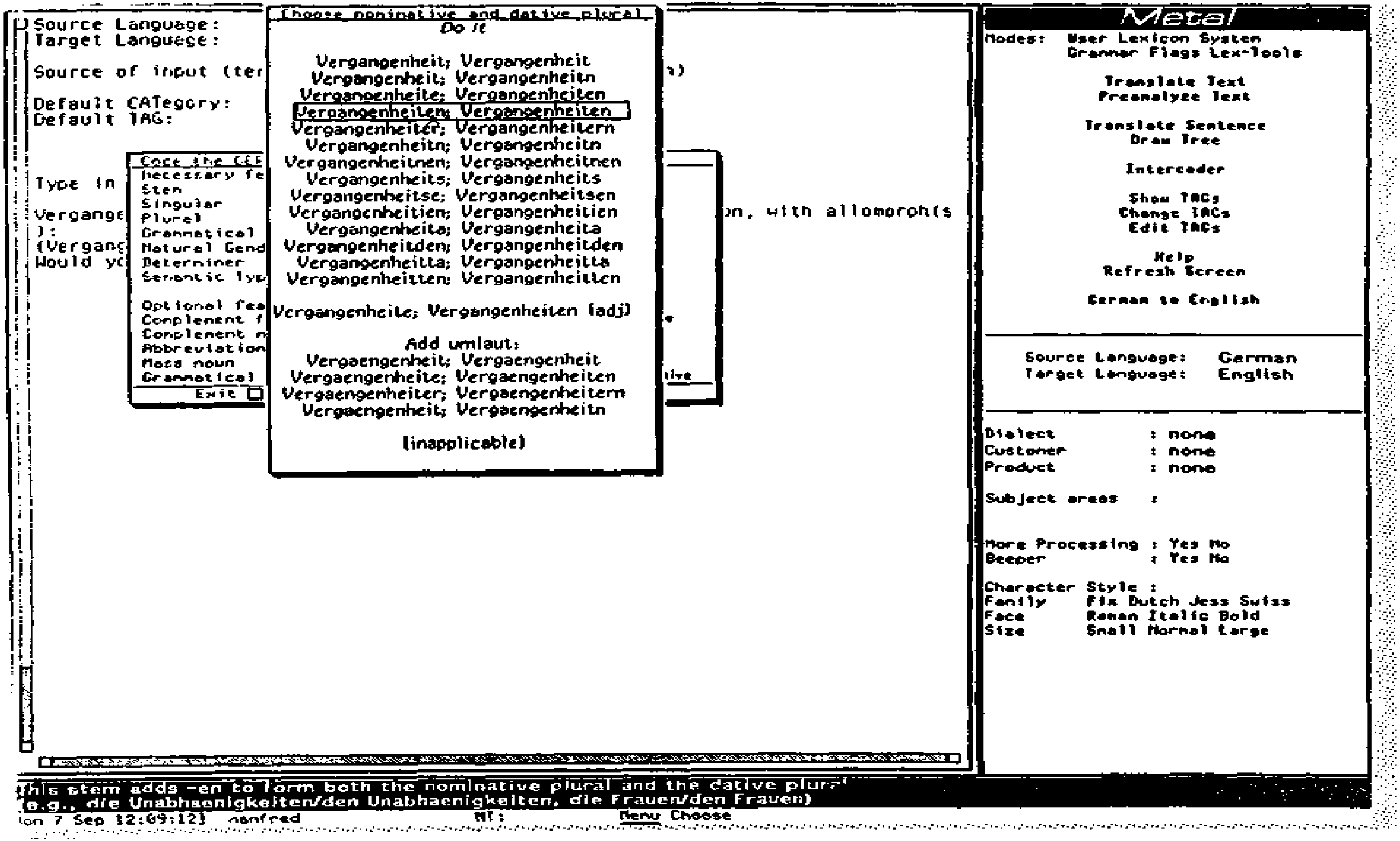


Figure 15.3 Intercoder screen with pop-up window showing possible inflection paradigms

Exhibit A:
an original German text

CSE Spracheingabe-Geraete
Einfuehrungsschrift

1 Einleitung

Die Entwicklung der Halbleitertechnik, insbesondere der Mikroprozessoren, hat in den vergangenen Jahren neue Perspektiven fuer die EDV eroeffnet. Im Bereich der Datenerfassung wurde mit der Spracheingabe in den Computer ein langgehegter Wunsch erfuellt. Damit steht fuer diesen kostenintensiven Zweig der Datenverarbeitung ein Verfahren zur Verfuegung, das die Benutzerfreundlichkeit entscheidend verbessert, zumal die bisherigen Erfassungsmethoden, die sich der Tastatur bedienen, im Prinzip eine Anpassung des Menschen an die Maschine erforderten.
Um die Datenerfassung schneller und sicherer zu machen, muessen die Daten moeglichst am Ort ihres Entstehens erfasst werden. In einer Reihe von Anwendungen ist dies mit Tastaturen problematisch, wenn nicht gar unmoeglich.
Dies ist dann der Fall, wenn der Benutzer mobil sein muss, die Haende fuer andere Taetigkeiten frei bleiben sollen, oder die Umweltbedingungen fuer Tastaturen ungeeignet sind.
Die Spracheingabe bietet hier eine ideale Loesung. Gegenueber den traditionellen Erfassungsmethoden zeichnet sie sich durch folgende Eigenschaften aus:

- Optimale Anpassung an die vom Menschen als natuerlich empfundenen Kommunikationsgewohnheiten
- Geringe Einarbeitungszeit
- Leichte Bedienung auch durch ungeuebtes Personal
- Mehr Bewegungsfreiheit fuer den Benutzer beim Erfassen der Daten
- Vereinfachte direkte Datenerfassung
- Groessere Sicherheit der Eingabe.

Die COMPUTER GESELLSCHAFT KONSTANZ bietet folgende Spracheingabegeraete an:

CSE 1050
CSE 1060*).

Die CSE-Geraete lassen sich an Rechner aller bekannten Hersteller anschliessen.
*) Computer-Sprach-Eingabe

2 Technik der Spracherkennung

2.1 Ueberblick

Unter Spracheingabe verstehen wir die Eingabe von Daten per Sprache in den Computer. Dabei wird das gesprochene Wort durch Spracheingabegeraete, die dem Computer vorgeschaltet werden, in maschinell verarbeitbare Information umgewandelt. Beim Erkennungsvorgang wird das Sprachsignal zunaechst in ein Bitmuster umgesetzt. Das Spracheingabegeraet vergleicht daraufhin dieses Muster mit den gespeicherten Mustern des Wortschatzes. Wird eine ausreichende Uebereinstimmung mit einem der Woerter des Wortschatzes festgestellt, gilt dieses Wort als erkannt. Im andern Fall weist das Geraet die Eingabe zurueck.
Der Wortschatz selbst wird zuvor durch ein Training, bei dem jedes Wort mehrfach einzusprechen ist, eingerichtet.
Der typische Datenfluss bei der Spracheingabe sieht wie folgt aus:
Bild 1 Typischer Datenfluss bei Spracheingabe

Die ueber Mikrofon eingesprochenen Woerter werden nach ihrer Erkennung vom CSE-Spracheingabegeraet in Form eines vereinbarten Codes ueber eine genormte Schnittstelle an den Computer weitergegeben. Dieser fuehrt die anwendungsspezifische Verarbeitung durch. In vielen Faellen ist es dabei nuetzlich, dem Benutzer mitzuteilen, welche Daten im Anwenderprogramm des Computers angekommen sind. Diese Rueckmeldung wird durch eine optische oder andere Anzeige, z.B. des erkannten Wortes, erreicht.

2.2 Der Erkennungsvorgang

Technisch koennen beim Vorgang der Spracherkennung zwei Schritte unterschieden werden:

- Die Vorverarbeitung des akustisch-phonetischen Signals
- Die Klassifizierung

Exhibit B:
a raw METAL translation
(February, 1984)

CSE voice data entry devices
Introduction

1 Introduction

The development of semiconductor technology, in particular the microprocessors has opened the new prospects for EDV in the last years. In the range of data acquisition, a long-cherished wish was filled with voice data entry into the computer. with it, a method of operation which improves user convenience deciding is available for this cost-intensive branch of data processing, because required the previous acquisition methods which handle itself of the keyboard in the principle an adaptation of the human being to the machine.
In order to make data acquisition more faster/rapid and secure/sure, the data must be registered inasmuch as possible at the place of its generation. In a series of applications, this is problematic with keyboards, if not indeed impossible.
this is then case, if the user must be mobil, ought to remain the hands for other activities free, or are the environmental conditions unsuitable for keyboards.
Voice data entry offers an ideal solution here. As compared to traditional acquisition methods, it distinguishes qualities/characteristics following through itself:

- Optimal adaptation to the habits of communication felt by the human being as natural
- Short/low training period
- Easy operation through inexperienced users also
- more freedom of movement for the user during gathering the data
- Simplified direct data acquisition
- Larger security of the input.

The COMPUTER GESELLSCHAFT KONSTANZ offers following voice data entry devices:

CSE 1050
CSE 1060*).

The computer voice data entry devices allow follow the computer of all known manufacturers. *) Computer voice data input

2 Technology of speech recognition

2.1 Summary

By voice data entry, we mean the input of the data per language into the computer. Therewith the spoken word is transformed by the voice data entry devices which are pre-connected to the computer into machine readable information. First the voice signal is converted during recognition procedure into a bit pattern. The voice data entry device compares this pattern then with the stored patterns of the vocabulary. if a sufficient correspondence is determined with one of the words of the vocabulary, this word is valid as recognized. In andern case, the device refuses the input.
the vocabulary itself is previously through a training, with that every word mehrfach to speake ist, set up.
The typical data flow during voice data entry appears as follows:
Figure 1 Typical data flow during voice data entry

the words spoken over microphone are transferred interface after its recognition by the CSE voice data entry device in the form of a determined code via a genormte to the computer. This operates the application-specific processing through. In many cases, it is user-friendly with it to report to the user which data are arrived in the user program of the computer. This feedback is reached by an optical or other display, for example of the recognized word.

2.2 Recognition procedure

Two steps can be distinguished technically during the process of speech recognition:

- Preprocessing of the acoustic-phonetic signal
- Classification

Practical Consideration

- According to five years experimenting, correctness varied from 45% to 85% for the Metal system.
- This system indicated an average performance about 2+ seconds per unit word with Symbolics 3600 Lisp Machine, 512K and 36-bit words of physical memory.
- Improvements after particular objections;
  - coverage of the grammar was extended
  - the de-formatting and reformatting programs were redesigned
  - errors in the general system lexicon were corrected.