[From: *Translating and the Computer 14.* Papers presented at a conference… 10-11 November 1992 (London: Aslib 1992)]

ENGLISH-SWEDISH TRANSLATION DIALOGUE SOFTWARE

Hiyan Alshawi, David Carter, Steve Pulman and Manny Rayner
SRI International
Cambridge Computer Science Research Centre
23 Millers Yard, Cambridge CB2 1RQ, U.K.
hiyan@cam.sri.com, dmc@cam.sri.com, sgp@cam.sri.com, manny@cam.sri.com

Björn Gambäck
Swedish Institute of Computer Science
Box 1263, S - 164 28 KISTA, Stockholm
gam@sics.se

Abstract

The paper describes the BCI, a prototype interactive machine-translation system, constructed by connecting English and Swedish versions of the SRI Core Language Engine through a transfer component. Transfer takes place at the level of Quasi Logical Form (QLF), a contextually sensitive logical form representation which is deep enough for dealing with cross-linguistic differences. Theoretical arguments are presented to support the claim that QLF transfer represents a good compromise between the opposing paradigms of syntactic transfer and semantic interlingua-based MT. An annotated example dialogue is shown. A follow-on project, in which the BCI is used as the core of a spoken-language translation system, is briefly described.

1 Introduction

> ... The Japanese developers seem to agree ... that the technology they are looking at is dead-ended ... I asked the head of a major Japanese laboratory whether further progress in machine translation would come about from extensions to their systems or from entirely new technology. His answer was so prompt as to be abrupt: “From new technology”.
>
> - Bernard E. Scott, Logos Corporation,
> in an open letter to *Computational Linguistics,* 1990.

Between February 1990 and March 1991, SRI International and the Swedish Institute of Computer Science pursued a joint research project intended to investigate the feasibility of constructing a sophisticated semi-automatic machine translation system by configuring and adapting existing state-of-the-art components centered around the SRI Core Language Engine. The project resulted in a prototype system, the “Bilingual Conversation Interpreter” (BCI) which is capable of interactive translation between English and Swedish, using a vocabulary of about

1000 words and a broad range of possible grammatical constructions. This paper will give an overview of the project's design philosophy and the current state of implementation of the prototype BCI. In the final section, we describe briefly a follow-on project, which has just begun, in which the BCI is configured together with a speech recognizer and a speech synthesizer to form a spoken-language translation system.

We will begin by describing the BCI's position within the field of machine translation as a whole. It is at the moment generally accepted among researchers in the field that fully automatic high-quality machine translation is not feasible as a short-term prospect, except within extremely limited sub-domains. (The example *par excellence* is weather forecasts, as exemplified in the well-known TAUM-METEO system (Thouin (11))). Disregarding these, realistic projects must normally compromise, either by accepting low-quality output (which may subsequently be post-edited), or by allowing human interaction during the translation process to supply knowledge not directly available to the system.

We have chosen the second alternative, for the following reasons. Firstly, there is a large class of applications where two monolingual humans can achieve a goal by carrying out a dialogue in real time: for the sake of concreteness, we have during the project focussed on a hypothetical application, where the BCI is being used by a Swedish car-hire firm in order to communicate with an English customer[1]. Secondly, such an architecture allows practical systems to be built at the level of the current state of the art, while providing a smooth development path for future improvements. As the basis of natural language processing technology improves, less human interaction is required.

2 Translation by Quasi Logical Form transfer

The central technical idea in the BCI is the concept of Quasi Logical Form transfer. Here, we have attempted to create an intelligent compromise between the opposing paradigms of "syntactic (or semi-syntactic) transfer" and "knowledge-based interlingua", which we will first briefly summarize. In the syntactic transfer approach, which is in practice by far the more common one translation is carried out in three stages: the source-language text is transformed into a syntactic representation (most commonly some kind of tree-like structure), which is then *transferred* into a target-language counterpart. Finally, the target-language text is generated from its syntactic representation. Knowledge-based interlingua-based systems, in contrast, perform translation in two stages: the source text is reduced to a language-independent intermediate representation, and the target text is generated from it directly. Very few systems are of course completely pure examples of either approach; in particular, many architectures based on syntactic transfer also employ some interlingual semantic ideas, of which the most important is usually a version of

1 A similar, though less sophisticated, system for translation between Japanese and English is reported in (Miike et al, (7))

case-grammar. This does not, however, substantially affect the following discussion.

On the positive side, syntactic transfer is the easier alternative to implement, since the techniques of syntactic analysis (and to a lesser extent generation) are well-understood and relatively straightforward. However, the fact that different languages use widely different syntactic forms places a great burden on the transfer component, which becomes correspondingly more complex and harder to understand. To take an example from the English-Swedish language-pair: although the structures of *He hired a car* and the corresponding *Han hyrde en bil* are identical, transforming the sentence into a question already creates non-trivial problems. The Swedish inverts the word-order *(Hyrde han en bil?),* while the English introduces an auxiliary *(Did he hire a car*?), necessitating an extra rule. The problem is that the representation is too shallow to "factor out" each language's own way of forming questions. There tend to be many phenomena of this kind, which interact to form an exponentially growing set of complex transfer rules.

On the other hand, pure interlingua systems do not suffer from these problems, since the intermediate representation is not tied to any particular language. The difficulty is rather that too little is as yet known about formal knowledge-representation techniques to make it feasible to specify a robust interlingua for more than a small subset of natural language; moreover, even if the theoretical apparatus were present, transformation to a language-independent form in general requires access to vast quantities of implicit "common-sense" knowledge, the formalization of which is a Herculean task. Although interesting experimental systems have been developed (for example, at Carnegie-Mellon University's World Center for Machine Translation), it seems unlikely that they can be turned into robust products in the short- or medium-term.

Our architecture is half-way between the two positions outlined above. The source text is analyzed into a representation ("Quasi Logical Form", or QLF), which has been carefully designed so as to represent exactly the aspects of linguistic meaning which do *not* involve context or "common-sense" knowledge. The source QLF representation is transferred into a target counterpart, from which target-language generation is used to produce the target text. In other applications, such as NL query interfaces to databases, the QLF representation would be subjected to further phases of processing; contextually determined factors, such as the referents of pronouns may be added, (Alshawi, (1)), and vague linguistic predicates replaced by more precisely defined relations (Rayner and Alshawi (9)). However, our hypothesis has been that a useful translation can be obtained by performing transfer directly on QLFs, when necessary dealing with problems of contextual interpretation by querying the user. These questions are phrased in such a way as to assume no knowledge on the source-user's part of either linguistics or the target language.

Our judgement, based on the experience gained during the first year of the project, is that QLF-based transfer successfully circumvents many of the difficulties that arise using pure transfer or interlingua methods; it manages to factor out the problems caused by linguistic differences, which are reasonably tractable, and leaves those caused by knowledge, which are not. The result is a robust and modular architecture, which can be debugged and expanded with a relatively low expenditure of effort. In the next section, we describe the BCI prototype in more detail: a full description is available in the final project report (Alshawi et *al* (4)).

3 Current status of the BCI prototype

The main components of the BCI are two copies of the SRI Core Language Engine (CLE; Alshawi (2)), a state-of-the-art general-purpose tool for natural-language analysis and generation, equipped with English and Swedish grammars respectively. The basic system software and the English grammar and lexicon were written at SRI Cambridge Research Centre between 1986 and 1989, with an expenditure of about fourteen man-years of work. Adaptation of the English-language components to Swedish was done at SICS during 1990-91, and took about 16 man-months. The two copies of the CLE are linked by the transfer and interaction components, which are comparatively small pieces of software; the transfer component consists of an interpreter and a set of declarative transfer rules which can be extended in a modular way. The system is normally run on a pair of Sun SPARCstations under either Quintus or SICStus Prolog. The overall architecture of the system is shown in Figure 1.

The CLE is capable of running both in analysis and generation modes, using a single grammar which is compiled in different ways for the two tasks; generation is performed using the Semantic Head-Driven algorithm (Shieber *et al* (10)). Analysis turns sentences into QLF representations, while generation works in the opposite direction. Intermediate stages include processing of morphology and syntax (grammar).

The QLF notation is a conservatively extended version of first-order logic, and is perhaps best described here by illustration. Continuing the example from the first section, *He hired a* car gives the QLF

```
[past,                                    ; in the past
 [hire_3p,                                ; the 3-place relation "hire"
  qterm(ex,sing,A,[event,A]),             ; obtained between an event,
  a_term(ref(pro,he,sing,l([])),B,        ; a male person referred to
         [and,[male,B],[personal,B]]),    ; by the singular pronoun "he",
  qterm(a,sing,C,[car1,C])]]              ; and a car
```

while *Did he hire a car?* is

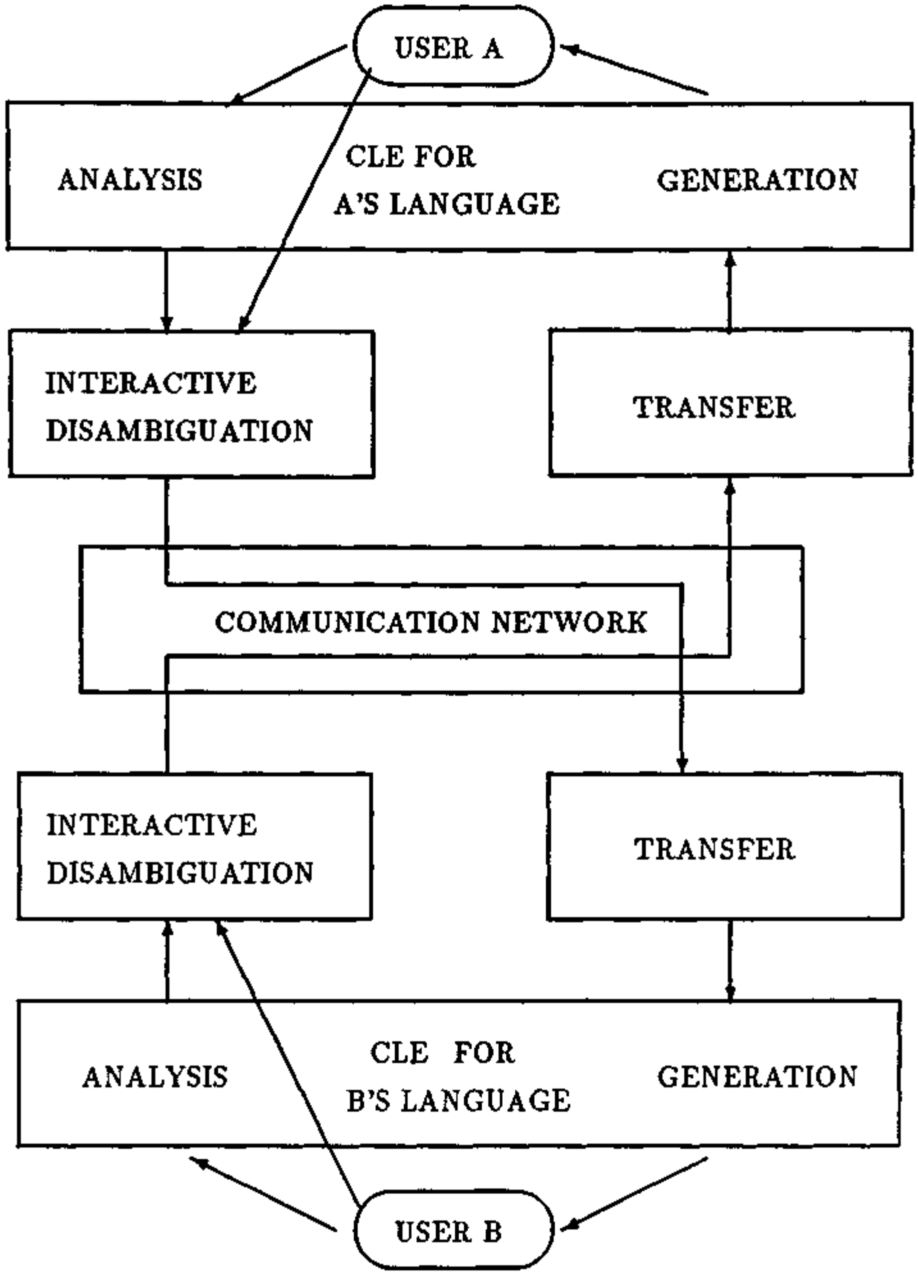

Figure 1: The BCI architecture

```
[ynq,                                        ; yes-no question: is it true that
 [past,                                      ; in the past
  [hire_3p,                                  ; the 3-place relation "hire"
   qterm(ex,sing,A,[event,A]),               ; obtained between an event,
   a_term(ref(pro,he,sing,l([])),B,          ; a male person referred to
          [and,[male,B],[personal,B]]),      ; by the singular pronoun "he",
   qterm(a,sing,C,[car1,C])]]]               ; and a car
```

The main point to notice is that the representation of the second sentence differs from that of the first only by having the operator ynq ("yes-no question") wrapped round it. This principle of cleanly separating out distinct aspects of the sentence in its QLF representation is adhered to consistently, and as explained above greatly simplifies the transfer process.

The English and Swedish grammars are both fairly large and cover most of the common constructions in their respective languages, including questions (YN- and WH-), topicalized clauses, imperatives, passives, relative clauses, negation, cleft constructions, conjunction, noun-phrase and verb-phrase modification by preposition-phrases, adjectives and adverbs, various kinds of complex determiners, proper names, dates and times, possessive constructions and about fifty different kinds of complements to verbs and adjectives. There is a good treatment of inflectional morphology, which for Swedish covers all main inflectional classes of nouns, verbs and adjectives.

The function-word lexicon for each language contains about 500 words, including most pronouns, conjunctions, prepositions, determiners, particles and "special" verbs. In addition, there is a "core" content-word lexicon with common nouns, verbs and adjectives, containing about 1000 entries.[2] New lexicon entries can be added by users using a tool developed for the purpose.

The BCI has been debugged using a test-set of about 400 sentences mainly taken from the hypothetical car-hire domain. The current level of robustness of the prototype is that of a fairly good "demo" system. For short sentences typical of the car hire domain, median total processing times for analysis, transfer and generation are around ten seconds when running under Quintus Prolog on a Sun SPARCstation 2.

A short sample dialogue is shown on the next page: "Client" refers to the English-language user, while "Agent" is his Swedish-language counterpart. Glosses for the Swedish text are in italics, and some of the less interesting disambiguation questions asked by the system have been omitted for the sake of brevity.

It should be apparent that the BCI's output, while perhaps not perfectly idiomatic, is nevertheless of a good standard and is readily comprehensible. Note also that non-trivial translation is possible, as evidenced for example in the seventh sentence, where the expression *Det går att*

---

[2] **The English CLE can also access the MRC lexical database, making it possible to construct on-the-fly part-of-speech entries for another 100000 words.**

Client:	I want to hire a car.		
		System to Agent:	"Jag vill hyra en bil" *(I want hire a car)*
		Agent:	Skulle du vilja ha en Volvo? *(Would you want have a Volvo?)*
		System to Agent:	What does "en" mean? 1 någon *(some)* 2 precis en *(one)* Enter a number: 1
System to Client:	"Would you like to have a volvo"		
Client:	I don't like Volvoes.		
		System to Agent:	"Jag tycker inte om Volvoar" *(I think not of Volvoes)*
		Agent:	Vi har en Saab och en liten Audi.
System to Client:	"We have a saab and a small audi"		
Client:	Can I pick up a Saab at the airport at 20:45?		
System to Client:	Consider the following bracketings... 1: can i {pick up a saab} at the airport at 20:45 2: can i pick up {a saab at the airport} at 20:45 Enter the number of one you like, or minus the number of one you don't like: 1		
		System to Agent:	"Kan jag hämta en saab vid flygplatsen 20.45?" *(Can I collect a Saab at the-airport 20.45?)*
		Agent:	Jag tror att kontoret där stänger klockan 19:00. *(I think that the-office there closes o'clock 19:00)*
System to Client:	"I think the office there is closing at 19.00"		
		Agent:	Det går att hämta bilen från kontoret i staden *(It goes to collect the-car from the-office in the-city.)*
System to Client:	"It is possible to pick the car up from the office in the city"		
Client:	OK, where is it?		
		System to Agent:	"Okay var är den/det" *(OK where is it (common)/it (neuter)?)*
		Agent:	Det är vid Slussen.
System to Client:	"That is at Slussen"		
Client:	Thankyou!		
		System to Agent:	"Tack"

Table 1: A typical BCI dialogue. A horizontal line indicates that processing of the previous message is complete.

(literally: “It goes to”) is rendered as *It is possible to.*

4 A speech-to-speech translation system based on the BCI

In this final section, we briefly report on a new project, aimed at construction of a prototype speech-to-speech translation system, in which the BCI appears as a component; the other main components are the SRI DECIPHER speech recognizer (Murveit, Butzberger and Weintraub (8)), and the Swedish Telecom Prophon speech synthesizer (Backström, Ceder and Lyberg (5), Ceder and Lyberg (6)). The project is being sponsored by Swedish Telecom; it started in August 1992, and is initially planned to run for one year. At the end of this period, the intention is to be able to demonstrate a prototype system which will translate spoken English into spoken Swedish, using a vocabulary of between 700 and 1000 words. The proposed architecture of the system is sketched out in Figure 2.

The system’s domain will be defined by the well-known ATIS corpus, a collection of about 10000 sentences relating to air travel information. Typical examples of sentences from the corpus are displayed below.

```
LIST FLIGHTS FROM DENVER TO BALTIMORE.
I'D LIKE TO GO AT FIVE FORTY.
WHAT MEALS ARE SERVED ON EASTERN FLIGHT SEVENTY.
SHOW ME THE MORNING FLIGHTS FROM BOSTON TO PHILADELPHIA.
I WOULD LIKE TO PLAN A FLIGHT ON AMERICAN AIRLINES.
HOW MUCH DOES IT COST TO USE THE AIR TAXI.
WHAT IS THE LEAST EXPENSIVE FLIGHT BETWEEN BOSTON AND SAN FRANCISCO.
SHOW ME THE ROUND TRIP FARE FOR THE U S AIR FLIGHT.
WHAT FLIGHTS GO FROM PHILADELPHIA TO SAN FRANCISCO WITH A STOPOVER IN DALLAS.
```

It is obviously too early to make any definite promises about the outcome of the project, but it should be noted that the BCI has several concrete strengths in this type of application when compared to other MT architectures. Firstly, the high quality of the translation output becomes doubly important when dealing with spoken language, since post-editing is in the nature of things impractical. Secondly, the fact that the Core Language Engine is basically a general natural-language processing device greatly simplifies the task of switching domains (in this case, from car hire to airline reservations); in fact, a preliminary adaptation of the English CLE to the ATIS domain already produces plausible analyses for over 80% of the corpus sentences under 15 words in length. We expect to be able to report on this work in more detail towards the beginning of 1993.

References

1. Alshawi, H. (1990) “Resolving Quasi Logical Forms”. *Computational Linguistics* Vol. 16, pp. 133-144.
2. Alshawi, H., ed. (1992). *The Core Language Engine.* Cambridge, Massachusetts: The MIT Press.
3. Alshawi, H., D. Carter, B. Gambäck and M. Rayner “Translation through Quasi Logical Form Trans-Fer” (1991). *Proceedings of the 29th Annual Meeting of the Association for Computational Linguistics,* University of Berkeley, California.
4. Alshawi, H., C.G. Brown, D. Carter, B. Gambäck, S. Pulman and M. Rayner (1991). *Bilingual Conversation Interpreter: A Prototype Interactive Message Translator. Final Report.* Joint SICS/SRI research report.
5. Backström, M., K. Ceder and B. Lyberg (1989). “Prophon - an Interactive Environment for Text-to-Speech Conversion”, *Proceedings of the European Conference on Speech, Communication and Technology,* Paris, CPC Consultants Ltd, Edinburgh, UK.
6. Ceder, K. and B. Lyberg (1990). “The Integration of Linguistic Levels in a Text-to-Speech Conversion System”, *Proceedings of the International Conference on Spoken Language Systems,* Kobe, Japan.
7. Miike, S., K. Hasebe, H. Somers, and S. Amano (1988) “Experiences with an on-line translating dialogue system”. *Proceedings of the 26th Annual Meeting of the Association for Computational Linguistics*, State University of New York at Buffalo, Buffalo, New York, pp. 155-162.
8. Murveit, H., J. Butzberger and M. Weintraub (1991). “Speech Recognition in SRI’s Resource Management and ATIS Systems”. *Proceedings of the Speech and Natural Language Workshop,* Morgan Kaufmann.
9. Rayner, M., and H. Alshawi (1992). “Deriving Database Queries from Logical Forms by Abductive Definition Expansion”. *Proceedings of the 3rd Conference on Applied Natural Language Processing,* Trento, Italy.
10. Shieber, S.M., G. van Noord, F.C.N. Pereira and R.C. Moore (1990). “Semantic-Head-Driven Generation”. *Computational Linguistics,* Vol. 16, pp. 30-43.
11. Thouin, B. (1982). “The Meteo System”, in V. Lawson (ed.) *Practical Experience of Machine Translation.* Amsterdam, Holland: North-Holland, pp. 39-44.

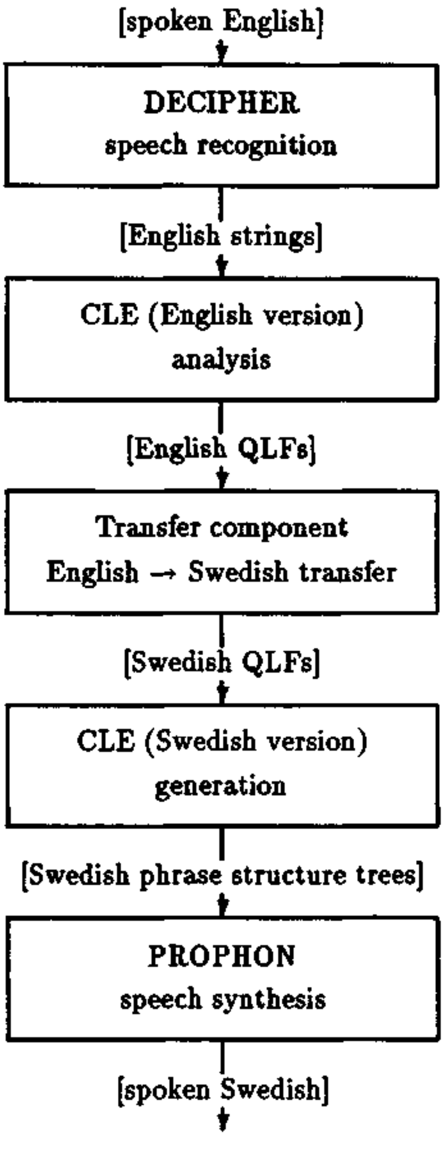

Figure 2: Architecture of the Spoken Language Translation System