Active Schenata
And Their Role
In Semantic Parsing

Joachim H. Leubsch
Institut fuer Informatik
Universitaet Stuttgart
D-7000 Stuttgart
West Germany

Dietmar P. Roesner
Mathematisches Institut A
Universitaet Stuttgart
D-7000 Stuttgart
West Germany

Abstract
In the past years we have been applying semantic
ATN-grammars - as introduced by Brown & Burton
(1974) - to natural language question-answering
tasks (e.g. a LISP-Tutor [Barth, 1977], a
question-answering system about the micro-world
of soccer [Rathke & Sonntag, 1979]). We found
that semantic grammars execute efficiently, but
become large very quickly even with moderate
domains of discourse. We therefore looked for
ways to support parsing by domain-dependent
knowledge represented in an inheritance network
[Leubsch, 1979]. In this paper we first briefly
describe our representation language ObjTalk,
and then illustrate how it is used for building
an understanding system for processing German
newspaper texts about the job market situation.

Keywords: newspaper processing, ATN, frames,
semantic grammar, object-oriented
programming, ObjTalk

Concepts as active schemata
We have developed an object-oriented
representation language - called ObjTalk - in
which objects are frame-like data structures
which have behavioral traits and communicate
through message passing. The objects (classes
and instances) are organized into a (multiple)
inheritance hierarchy. ObjTalk is an extension
to Lisp and was inspired by SMALLTAL
[Goldberg & Kay, 1976], FEL [Roberta & Goldstein,
1977], and KLONE [Brachman, 1978].

An inheritance net of objects (with the root
class Object) is constructed by sending the
message NEW: to the class CLASS, i.e. a concept
definition in ObjTalk has the form:

(ASK CLASS NEW: <concept-name>
SUPERC (<concept-name>...)
GENERIC-PROPERTIES
<slot-name>: <filler-description>
METHODS
<method-name>: [[<filter> => <body>]
...]
TRIGGER-ATN
<Trigger-keys> ; attached ATN
[<subATN-node> <production>]
...)

The effect of sending NEW: to CLASS is to define
a class with the given <concept-name> as a
subclass of the named superclass(es). Instances
are made by sending the concept a message that
causes to fill its slots with fillers which
satisfy the filler description. If an object
receives a message, this will be matched against
the method-filters. In case of success the
corresponding method's body will be evaluated.

Concepts inherit methods and generic properties
from their superclass(es) recursively up to the
root node Object (which implements the
system-defined messages). Objects may be further
specified dynamically by adding slots or
methods, or filling slots.

For schema-driven parsing, a semantic subATN
should be activated whenever a particular word
is found, or concept is expected. The basic
mechanism is to attach trigger-keys to a schema
that state which words
which words or concepts make a schema active. Once active it puts the named subATN-nodes in a preferred activatable state. The ATN-machine has been extended to prefer PUSH arcs from non-deterministic states if they are activatable. This is implemented by primitives for activating a subATN, deactivating an active one, and a test for activation.

The subATNs of the trigger-atn form (or those ones in filler descriptions) are made activatable if

(1) a concept has been partially instantiated (an instance of this concept or one lower in the hierarchy was made, but not all obligatory roles are filled), or

(2) one of the concepts mentioned in trigger-keys has been instantiated, or

(3) one of the words mentioned in trigger-keys was found by the scanner.

Arc actions of the ATN may send messages to concepts, and thus (partially) instantiate a concept.

Application to newspaper understanding

We are currently applying ObjTalk to understanding newspaper reports about the jobmarket situation. Reports of this kind are highly stereotypical: They describe the present jobmarket situation in terms of a few attributes and their respective changes. These indicators are interpreted and discussed within the framework of a simple model of jobmarket fluctuations by officials of the issuing organization. Sometimes the data are also commented upon by political speakers of different views.

Jobmarket reports are prototypical for related "official statistical reports" (e.g. developments of population, crime, stockmarket etc.). These articles are differing in structure and contents (data, values, changes, explanations, interpretations) from the more "event"-oriented newspaper-texts of DeJongs TRUMP [1979] and Cullingfords SAM [1978].

The knowledge-base

We have built a knowledge-base of (ObjTalk-) concepts in order to process news articles of this type. The design was guided by the principle of providing an active schema for everything that would be considered a "thema" in the reports.

The most global frame is the one for "job-market-situation" (jms). It combines in its roles all what would "normally" be reported in our texts and should therefore be expected by the system: time, region, relevant aspects or indicators - i.e. joblesse-rate, open-jobs, new employments ... - explanations for the general situation, general predictions. (Think of a jms-frame as a "snapshot" of the jobmarket-developments; Schankian people may think of it as analogous to a script).

The relevant aspects are in a sense constituting the jms, technically spoken: are in a part-of relation to the jms-frame. Their frames themselves are combined from frames for the static and the dynamic part of the jobmarket-factor, i.e. an index- and an index-change-frame. Each concept for an individual jobmarket-aspect also involves encoded knowledge for a (specific) evaluation, explanation and prediction.

The common traits of the individual jm-indices are organized in the jm-index-frame, which itself inherits knowledge (slots,...) from a more general index-frame that combines the shared traits of all such indices (cf. above). This organization should later allow easy extension of the system.

Examples

Parsing the sentence

"DIE ZAHL DER ARBEITSLOSEN IN ENGLAND IST IM MAI UM 14000 AUF 1,509 MILLIONEN ZURUECKGEGANGEN"

("THE NUMBER OF UNEMPLOYED PERSONS IN ENGLAND HAS DECREASED IN MAY BY 14000 TO 1,509 MILLION")

would cause the following instances to be created and included into the static and dynamic roles of the resp. jm-aspect:
jobless-index-1 = (a jobless-index with
region: (England)
value: (1.509 million)
time: (DATE 5/80)
sex: (AND MALE FEMALE)
jobtypes: (ALL JOBTYPES)
changes: change-jobless-index-1
...)

change-jobless-index-1 = (a change-of-index with
ref.-index: jobless-index-1
time-new: (DATE 5/80)
time-old: (DATE 4/80)
time-interval: (DATE-YNT 5/80)
value-new: (1.509 million)
value-old: (1.523 million)
change-abs: (-14000)
change-qual: (DECREASE)
evaluation: (POSITIVE)
...)

(The last inference is done by a method of class
jobless-index which says that for this index
DECREASE is evaluated positively; this rule does
of course not hold for e.g. the
open-jobs-index).

Schemata for argumentations

Statements about facts are often followed by
explanations given by an official person. Such
statements are recognized and dealt with by a
schema called "interpretation" which is
activatable e.g. by verbs like the German
"erklären" ("declare").

The interpretation schema has as roles:
fact: (OR (CLASS jm-indicator)
(CLASS jm-situation))
speaker: (CLASS official/person)
object: (CLASS explanatory/statement)

The object of an interpretation is an
explanatory statement, which has roles for a
manifest fact and supporting reasons. The system
has an elementary knowledge about (jm-specific)
economic dependencies (e.g. decrease in the
jobless rate in the time interval from March to
May may be due to seasonal effects), and uses
this to identify resp. utterances as reasons in
an explanatory statement.

Guiding ATN control through schemata

The kernel of our grammar consists of semantic
ATNs particular to role fillers of (ObjTalk-)
concepts. In general, the parser tries to use
the most specific subATN possible, and only
falls back onto a syntactic subnet if no
expectations are active.

The semantic subATNs may be rather idiosyncratic
(like the one for NP/jobmarket/official/person
to handle phrases like "DER PRÄSIDENT DER
BUNDESANSTALT FÜR ARBEIT IN NÜRNBERG,
JOSEF STINGL ...") and are organized hierarchically.
They may be used by diverse concepts with
similar slots. The value returned via the POP
arc of a subnet may be used directly as a fuller
for the triggering slot. A more general
interface between the ATN results and the slots
of a schema is provided by the productions in
the trigger-atn form. The production filters out
those parts of an ATN result that fit as
role-fillers of the concept.

Writing semantic ATNs is simplified by the
chance to specify only one generic PUSH arc
(e.g. NP) that processes a class, instead of the
possibly large set of more specific PUSHes (e.g.
NP/PERSON, NP/OFFICIAL/PERSON, NP/JOBMARKET/
OFFICIAL/PERSON, ...).

If the parser is in the starting state of such a
generic PUSH and a schema is active whose roles
are to be filled by semantic subATNs, then those
standing in subclass relation to the generic
PUSH are preferred. E.g., if an unfilled slot
expects a NP/PERSON, and the parser
expects a NP, then, since NP/OFFICIAL/PERSON
is a specialization of NP, it is activated and - in
case of success - the result is used to fill
that slot.

In general, several schemata can be active at a
time, in the sense that some of their slots are
unfilled. (In other words: There may be several
"thematic expectations" looking for further
information in the article). Then all of the
attached subATNs are activatable. It is possible
that an expected subATN succeeds but the result
fails to meet a fuller-restriction (or even does
not match the production). This is treated like
a failure of the subATN itself.
An informal parse

The following example - slightly shortened from a real news note - is intended to give a flavor of how knowledge base and parser processes cooperate in analyzing a jobmarket report:

>> Die Zahl der Arbeitslosen ..
   (The number of unemployed ..)
   This triggers the concept for a jobless-index and, since there is no one active yet, instantiates a jobmarket-situation as context for further processing. Within it, the jobless-index becomes the static part of the resp. jms-aspect-frame.

>> .. verringerte sich .. (.. decreased ..)
   An instance of change-of-index for jobless-index is created (because verbs like "decrease" are attached to index-changes) and identified as the expected dynamic part of the still active jms-aspect.

>> .. in Mai um 58000 auf 766000.
   (.. in may by 58000 to 766000.)
   Various unfilled slots in the active jobless-index and change-of-index schemas are filled by successfully processed particular PP-nets attached to those slots (e.g. PP/TIME-INT for time-interval), some slots get their default values, which reflect newspaper conventions of "what is known without having been said" (e.g. the region slot gets "western germany").

>> Der Präsident der Bundesanstalt für Arbeit, Joseph Stingl, erklärte ...
   (The president of the federal employment office, J.S., declared ..)
   This leads to the instantiation of an interpretation frame (which itself will fill the explanation slot of the jms-aspect) with the named official filling the speaker slot, and makes thus a schema for an explanatory statement active. Slots to be filled here are a manifestation and reasons.

>> .. Entwicklung am Arbeitsmarkt ..
   (.. the development on the jobmarket ..)
   This refers to the previously built change of jobless-index (as - by default - central aspect of jms-developments and - in this context - only "development" talked about so far). It becomes filler for the manifestation slot.

>> .. lässt keine konjunkturnellen Auftrags- 
   krafte mehr erkennen .. (.. does not show any signs of economic recovery, ..)
   Since the manifest fact may be explained by economic recovery or other reasons, the intent of this statement is to exclude the former explanation. The exclusion of a reason activates a more general argumentation schema which now demands that a positive explanation must follow (at least in well written texts).

>> .. der Rückgang der Arbeitslosigkeit set nur 
   auf saisonale Einflussse zurückzuführen.
   (.. the decrease in jobless rate is only caused by seasonal influences.)
   The first part repeats the manifestation (and is optional), and the second part claims seasonal effects as reason for it. This explanation is confirmed by one of our inference rules ( time-interval is May ) about the relations between season and changes in jobmarket-indices. This finally allows to fill the reason slot of the explanatory statement.

REFERENCES

Barth, M. "Zur Implementierung eines Lehrsystems für LISP." Diplomarb. 62, IFI-UNI Stuttgart, 1977.

Brachman, R.J. "A Structural Paradigm for Representing Knowledge." BBN Rep. No. 5609, Cambridge, 1978.

Brown, J.S., Burton, R.R. & Bell, A.G. "SOPHIE - a Sophisticated Instructional Environment for teaching electronic trouble-shooting." BBN Rep. 2790, Cambridge, 1974.

Cullingford, R.E. "Script Application: Computer Understanding of Newspaper Stories" Res.Report #116, Yale, 1978.

DeJong, P.D. "Scanning Stories in Real Time: An Experiment in Integrated Understanding" Res.Report #158, Yale, 1979.

Goldberg, A. & Kay, A. (Eds.) "SMALLTALK-71 Manual." XEROX PARC, Palo Alto, 1976.

Laubsch, J.H. "Interfacing a semantic net with an augmented transition network." Proc. 6th Inter. Conf. on Artificial Intelligence, Tokyo, 1979.

Rathke, Ch. & Sonntag, B. "Einsatz semantischer Grammatiken in Frage/Antwort-Systemen, Teil I + II." Diplomarb. 240 & 251, TPT-UNI Stuttgart, 1979.

Roberts, B.B. & Goldstein, I.P. "The PRL Manual." MIT-AI Memo 409, Cambridge, 1977.

Rosenberg, S.T. "Frame-based Text Processing" MIT-AI Memo 431, Cambridge, 1977.