

A Computational Treatment of Korean Temporal Markers,

OE and *DONGAN*

Hyunjung Son
EHSS
54, Boulevard Raspail
75006 Paris France
hyunjung_son@hotmail.com

Abstract

In this paper, we elucidate how Korean temporal markers, *OE* and *DONGAN* contribute to specifying the event time and formalize it in terms of typed lambda calculus. We also present a computational method for constructing temporal representation of Korean sentences on the basis of G grammar proposed by [Renaud, 1992;1996].

1 Introduction

Associated to a NP, Korean temporal markers *OE* and *DONGAN* build time adverbials.

(1) *ach'im ilgopshiOE*
morning/seven o'clock-*OE*
at seven o'clock in the morning

(2) *han shigan DONGAN*
one/hour/*DONGAN*
for an hour

As it is widely known, time adverbials play important roles in sentence meaning processing. Meanwhile, there is a significant divergence in opinions whether time adverbials or tense/aspect is a more efficient indicator leading to a correct temporal representation of sentences. To some [Kim, 1981], [Jo, 2000], [Vet, 1980], [Verkyul, 1989], tense or aspect is the only credible index to consult in establishing temporal interpretation, and the time adverbials are complementary. To others [Renaud, 1996], [Vlach, 1993], time adverbials are regarded as much more reliable than tense/aspect which is too ambiguous to provide coherent

instructions about how to locate the event in time. We agree with the second point of view, as we observed that Korean tense markers fail to provide a solid and coherent way to capture the relevant time span. For example, the verbal infix '-at-', generally considered as a typical past tense marker in Korean, brings about several time interpretation possibilities such as simple past (3), completion (4), resultant state (5) and progressiveness (6).

(3) *shiwidaega ôje hanshiOE shich'ôngul dulrôssatta*
demonstrators-NOM / yesterday /one o'clock-*OE* /
the city hall-ACC/ surround-PA-DEC¹
The demonstrators surrounded the city hall at one o'clock yesterday.

(4) *shiwidaega mach'imnae shich'ôngul dulrôssatta*
demonstrators-NOM / at last / the city hall-ACC
/surround-PA-DEC
At last, the demonstrators surrounded (succeeded in surrounding) the city hall.

(5) *shiwidaega harudongan shich'ôngul dulrôssatta*
demonstrators-NOM/one day-DUR/the city hall-ACC/surround-PA-DEC
The demonstrators have surrounded the city hall for one day.

¹ We used the McCune-Reischauer system to transcribe the Korean data. For glossing grammatical morphemes, we use the following abbreviations:
ACC: accusative, AS: attributive suffix, CIRCUM: circumstantial, CL: classifier, DEC: declarative, DUR: durative, INT: interrogative, LOC: locative, NOM: nominative, NS: nominal suffix, PA: past, TOP:topic.

(6) *ônjebutô shiwidaega shich'ôngul
dulrôssatssumnikka?*

since when/ demonstrators-NOM/ the city hall-
ACC/ surround-PA-INT

Since when have the demonstrators been
surrounding the city hall?

Moreover, what triggers these interpretation
possibilities is still being discussed among Korean
linguists².

In the following, we attempt to show how time
adverbials can remedy this shortcoming and
specify the event time.

2 Semantic description

The assumption underlying our temporal
description is that the linguistic time is ordered,
discrete, infinite and consisting of instants
corresponding to the natural numbers. The
linguistic time can be expressed with one of these
three notions: instant, extended interval and
duration. Instants are unitary constituents of
linguistic time and noted by a quintuplet of natural
numbers [x1,x2,x3,x4,x5] of which x1 stands for
year, x2 for month, x3 for day, x4 for hour and x5
for minute.

(ex) at 3 o'clock on April 5th 2003: instant
[2003,4,5,3,0]

An extended interval is a set of consecutive
instants determined by a beginning instant and an
ending instant.

(ex) on April 5th, 2003: interval
[[2003, 4,5,0,0], [2003,4,5,23,59]]

A duration refers to a temporal distance between
two distinct instants.

(ex) for 5 years: duration [5,_,_,_,_]

For the purpose of temporal description of a
sentential event, we defined the following types
and functional terms on the basis of typed lambda

² See [Jo, 2000], [Lee, Ch., 1987], [Lee, H., 1993] and
[Lee, J., 1982] for more detailed discussion.

calculus³. The symbol λ stands for abstraction and
 \bullet stands for application⁴.

Definitions of types

i : type symbol denoting the type of individuals

p : type symbol denoting the type of propositions

e : type symbol denoting the type of events

ent: type symbol denoting the type of natural
numbers

inst : type symbol denoting the type of instants

inter : type symbol denoting the type of extended
intervals

dur: type symbol denoting the type of durations

Type symbols may be omitted when no ambiguity
is introduced.

Definitions of functional terms

(λe . moment $\bullet e$): $e \rightarrow inst$

Applying this function to any argument of type *e*,
we obtain the moment of *e* of type *inst*.

(λe . interv $\bullet e$): $e \rightarrow inter$

Applying this function to any argument of type *e*,
we obtain the interval of *e* of type *inter*.

(λx . beginning $\bullet x$): $e \rightarrow inst$

(λx . ending $\bullet x$): $e \rightarrow inst$

Applying these functions to any argument *x* of
type *e*, we obtain the beginning/ending instant of *x*
of type *inst*.

(λx . duration $\bullet x$): $e \rightarrow dur$

Applying this function to any argument *x* of type
e, we obtain the duration of *x* of type *dur*.

(λx . beg $\bullet x$): $inter \rightarrow inst$

(λx . end $\bullet x$): $inter \rightarrow inst$

Applying this function to any argument *x* of type
inter, we obtain the beginning/ending instant of *x*
of type *inst*. By definition, beg \bullet [A,B] = A and
end \bullet [A,B] = B

³ [Andrews, 1986 ; 2002], [Hindley et al., 1986] and
[Renaud, 1996].

⁴ If M and N are lambda-terms, then M \bullet N is a lambda-
term.

$(\lambda x. \text{length}\bullet x): \text{inter} \rightarrow \text{dur}$

Applying this function to any argument x of type *inter*, we obtain the length of x of type *dur*. By definition, $\text{length}\bullet[A,B]=|B-A|$

$(\lambda x \lambda y. x <_{\langle t \rangle} y): \text{inst} \rightarrow \text{inst} \rightarrow \text{p}$

It denotes that x of type *inst* is anterior to y of the same type. When no ambiguity is introduced, $\langle t \rangle$ will be omitted.

$(\lambda x \lambda y. x =_{\langle t \rangle} y): \text{inst} \rightarrow \text{inst} \rightarrow \text{p}$

It denotes that x and y of type *inst* are simultaneous.

$(\lambda x \lambda y. x \leq_{\langle t \rangle} y): \text{inst} \rightarrow \text{inst} \rightarrow \text{p}$

It denotes that $\lambda x \lambda y. (x <_{\langle t \rangle} y \vee x =_{\langle t \rangle} y)$.

$(\lambda x \lambda y. x \in_{\langle t \rangle} y): \text{inst} \rightarrow \text{inter} \rightarrow \text{p}$

It denotes that x of type *inst* is a member of y of type *inter*. By definition, $\lambda x \lambda y. (\text{beg}\bullet y \leq x \leq \text{end}\bullet y)$

$(\lambda x \lambda y. x \subset_{\langle t \rangle} y): \text{inter} \rightarrow \text{inter} \rightarrow \text{p}$

It denotes that x of type *inter* is included by y of the same type. By definition, $\lambda x \lambda y. (\text{beg}\bullet y < \text{beg}\bullet x \wedge \text{end}\bullet x < \text{end}\bullet y)$.

$(\lambda x \lambda y. x =_{\langle t \rangle} y): \text{inter} \rightarrow \text{inter} \rightarrow \text{p}$

x and y of type *inter* are simultaneous. By definition, $\lambda x \lambda y. (\text{beg}\bullet x = \text{beg}\bullet y \wedge \text{end}\bullet x = \text{end}\bullet y)$.

$(\lambda x \lambda y. x \subseteq_{\langle t \rangle} y): \text{inter} \rightarrow \text{inter} \rightarrow \text{p}$

It denotes that $\lambda x \lambda y. (\text{beg}\bullet y \leq \text{beg}\bullet x \wedge \text{end}\bullet x \leq \text{end}\bullet y)$.

The temporal adverbials with *OE* or *DONGAN* do not bring the same semantic constraints in all the sentences. It can be illustrated by the following examples of *OE* (7-10) and *DONGAN* (11-14).

(7) *ach'im ilgopshiOE nurôngoiga chugôtta.*

the morning /seven o'clock-*OE* / *Nurôngoi*-NOM /die-PA-DEC

At seven o'clock in the morning, *Nurôngoi* died.

The *OE* adverbial of this example indicates the moment when the event described by the nuclear sentence⁵ happened.

(sr 7) $\exists e \exists I \text{ die}\bullet e \bullet \text{nurôngoi}^6 \wedge$

$\text{moment}\bullet e < \text{pt_speech} \wedge$

$I = (7 \text{ o'clock}) \wedge \text{moment}\bullet e \in I$

But in (8) and (9), *OE* adverbials indicate an interval of which an instant is identified with the moment of the event.

(8) *samwol shiboirOE nurôngoiga chugôtta.*

March/the fifteenth-*OE* /*Nurôngoi*-NOM/die-PA-DEC

On the fifteenth of March, *Nurôngoi* died.

(sr 8) $\exists e \exists I \text{ die}\bullet e \bullet \text{nurôngoi} \wedge \text{moment}\bullet e < \text{pt_speech}$

$\wedge I = (\text{the } 15^{\text{th}} \text{ of March}) \wedge \text{moment}\bullet e \in I$

(9) *chinan yôrumOE nurôngoiga chugôtta*

the last summer-*OE* / *Nurôngoi*-NOM/die-PA-DEC

Last summer, *Nurôngoi* died.

(sr 9) $\exists e \exists I \text{ die}\bullet e \bullet \text{nurôngoi} \wedge \text{moment}\bullet e < \text{pt_speech}$

$\wedge \text{interval}\bullet I \wedge \text{summer}\bullet I \wedge \text{moment}\bullet e \in I$

Moreover, *OE* adverbials can introduce a period of recurrent events as in (10).

(10) *iljuirOE so dasôt mariga chugôtta*

a week-*OE*/cow/five/classifier-NOM/die-PA-DEC

Five cows died every week.

(sr 10) $\exists I \text{ interval}\bullet I \wedge \text{length}\bullet I = (7 \text{ days}) \wedge \exists J$

$\text{interval}\bullet J \wedge \exists P (\text{equi-partition}\bullet I \bullet P \bullet J \wedge \forall K (P \bullet K$

$\rightarrow |\lambda x. \text{cow}\bullet x \wedge \exists e \text{ die}\bullet e \bullet x \wedge$

$\text{moment}\bullet e < \text{pt_speech} \wedge \text{interv}\bullet e \subseteq K | = 5))$ ⁷

⁵ We call the independent sentences without modifiers such as temporal adverbials 'nuclear sentence'.

⁶ 'die•e•nurôngoi' is equivalent to die(e, nurôngoi) in predicate logic.

⁷ [Renaud, 2002] defines the equi-partition function as: equi-partition•D•P•N $\equiv (N = (\cup \bullet P) \wedge |P| > 2 \wedge \forall K1 K2 ((P \bullet K1 \wedge P \bullet K2 \wedge K1 \neq K2) \rightarrow$

$(\text{length}\bullet K1 = \text{length}\bullet K2 = D \wedge K1 \cap K2 = \emptyset)))$

where $\cup \bullet R \equiv \lambda x. \exists R (R \bullet P \wedge P \bullet x)$

As for *DONGAN* adverbials, they present the maximal duration of the described event as in (11).

(11) *hanshigan DONGAN kwanghoe bihaenggiga naratta*
 an hour /*DONGAN* /of *Kwangho* /airplane-NOM /fly-PA-DEC
Kwangho's airplane flew **for an hour**.

(sr 11) $\exists x \exists e \text{ airplane} \bullet x \wedge \text{of} \bullet \text{kwangho} \bullet x \wedge$
 $\text{fly} \bullet e \bullet x \wedge \text{ending} \bullet e < \text{pt_speech} \wedge$
 $\text{duration} \bullet e = (1 \text{ hour})$

In (12), the interval denoted by the *DONGAN* adverbial is included by that of the sentential event. In other words, it is not clear, for the moment, whether the described event reached its end or not.

(12) *kyôul banghak DONGAN ukyunun mokgongsoesô ilhaetta*
 winter vacation /*DONGAN* /*Ukyu*-TOP/carpenter's shop-LOC/work-PA-DEC
During the winter vacation, *Ukyu* worked at the carpenter's shop.

(sr 12) $\exists e \exists I \text{ work} \bullet e \bullet \text{ukyu} \wedge \text{at} \bullet e \bullet \text{carpenter's_shop} \wedge$
 $\text{beginning} \bullet e < \text{pt_speech} \wedge \text{interval} \bullet I \wedge$
 $\text{winter_vacation} \bullet I \wedge I \subseteq \text{interv} \bullet e$

DONGAN adverbials also indicate the interval to which the moment of the event belongs, as (13) shows.

(13) *kyôul banghak DONGAN nanun shine daehae saenggak'agi chijak'aetta*
 winter vacation / *DONGAN* / I-TOP/ about God/ think /begin-PA-DEC
During the winter vacation, I began to think about God.

(sr 13) $\exists I \exists e \text{ interval} \bullet I \wedge \text{winter_vacation} \bullet I \wedge$
 $\text{begin} \bullet e \bullet (\lambda e \lambda x. \text{think_about} \bullet e \lambda \text{god} \bullet x) \bullet \text{speaker} \wedge$
 $\text{moment} \bullet e < \text{pt_speech} \wedge \text{moment} \bullet e \in I$

The following example (14) denotes that fishing of Yunsôk has been repeated in a regular way during the interval indicated by the *DONGAN* adverbial.

(14) *shimnyôn DONGAN yunsôkun môn badaesô kokijabirul haetta*

10 years /*DONGAN* /Yunsôk-TOP /far ocean-LOC /fishing-ACC/do-PA-DEC

For ten years, Yunsôk fished in the far ocean.

(sr 14) $\lambda D. \exists P \text{ equi-partition} \bullet D \bullet P \bullet \text{int}_{\text{ref}} \wedge$
 $\exists H H = (\lambda J. (P \bullet J \wedge \exists e \text{ fish} \bullet e \bullet \text{yunsôk} \wedge$
 $\text{in} \bullet e \bullet \text{the_far_ocean} \wedge \text{ending} \bullet e < \text{pt_speech} \wedge$
 $\text{interv} \bullet e \subseteq J) \wedge$
 $\exists M \max \bullet (\lambda N. N \subseteq (\cup \bullet H) \wedge [\text{inferior} \bullet (\cup \bullet N),$
 $\text{superior} \bullet (\cup \bullet N)] \cap \text{int}_{\text{ref}} = \cup \bullet N) \bullet M \wedge \text{length} \bullet M =$
 (10 years)⁸

Such a distributional pattern of events disappears when the nuclear sentence is modified by quantification, which is illustrated by (15).

(15) *shimnyôn DONGAN yunsôkun môn badaesô kokijabirul se bôn haetta*
 10 years /*DONGAN* /Yunsôk-TOP /far ocean-LOC /fishing-ACC/three times/do-PA-DEC
 For ten years, Yunsôk had fished in the far ocean three times.

(sr 15) $\exists I \text{ interval} \bullet I \wedge \text{length} \bullet I = (10 \text{ years}) \wedge$
 $|\lambda e. \text{fish} \bullet e \bullet \text{yunsôk} \wedge \text{in} \bullet e \bullet \text{the_far_ocean} \wedge$
 $\text{ending} \bullet e < \text{pt_speech} \wedge \text{interv} \bullet e \subseteq I| = 3$

To find a strategy to solve such a multiple ambiguity, we investigated three thousand sentences for each temporal marker⁹ and discovered the following facts:

1. The semantic and syntactic properties of the phrase accompanying the temporal markers play an important role to locate the event in time.
2. It is necessary to distinguish mono-occurrent sentences concerning a single event from multi-occurrent sentences concerning a set of different events¹⁰. The multi-occurrent nature is very often

⁸ [Renaud, 2002] defines the function used in this formula as follows:

$\text{int}_{\text{ref}} \equiv \text{interval of reference}$
 $[\cup \bullet I] \equiv [\text{inferior} \bullet (\cup \bullet I), \text{superior} \bullet (\cup \bullet I)]$ where the brackets denote an interval.
 $\max \bullet E \bullet M \equiv (E \bullet M \wedge \neg \exists N (M \subset N \wedge E \bullet N))$

⁹ We took the sentences from *Yonsei malmunchi* corpus built by Yonsei Center for Linguistic Information.

¹⁰ [Renaud, 2002].

The time adverbial *hanshigan DONGAN* in (11) includes a NP denoting duration and conforms to the syntactic condition E¹². Thus, the semantic term of type t5 is assigned to this time adverbial.

We also calculate the semantic term of the nuclear sentence relying on criteria such as quantification modification, mono/multi-occurrent and aspect¹³, which get involved in the feature constraint at the levels of both dico and of rules. Since the nuclear sentence of (11) is not modified by quantification, and since it concerns a single event of activity, it receives a semantic term of type c3 in the following figure.

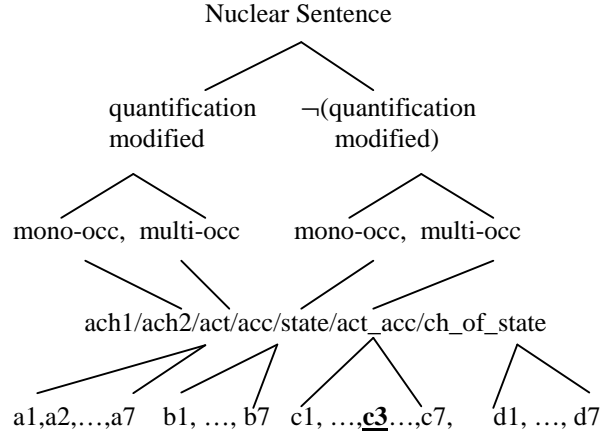


Figure 3. Processing of nuclear sentences

- ¹² *DONGAN* accepts seven different syntactic structures:
- A. Interval Noun + *DONGAN* (ex: summer vacations)
 - B. Interval NP + Duration NP + *DONGAN*
 - C. Deictic/anaphoric determiner + Duration NP + *DONGAN*
 - D. Attributive Clause + Duration NP + *DONGAN*
 - E. Duration NP + *DONGAN*
 - F. Attributive Clause + *DONGAN*
 - G. Anaphoric determiner + *DONGAN*

We excluded the last structure from our research because of its highly context dependent meaning.

¹³ Aspectual classification is done by the following method; first, we observed the compatibilities of nuclear sentences with linguistic expressions such as *-go innun chungida*, *mane* and *dongan*. And then we investigated whether *mane* indicates the preparatory stage of the concerned event and whether *dongan* marks the resultant state of the event. As a result, we obtained seven distinct combinations as follows.

	(1)	(2)	(3)
Verb+ <i>go innun chungida</i> (progressive verbal form)	-	+	+
Durative NP + <i>mane</i>	+/-	+	+
preparatory stage	+	+	-
Durative NP + <i>dongan</i>	-	-	-
Resultant state	-	-	-
	ACH1	ACH2	ACC

	(4)	(5)	(6)	(7)
Verbe+ <i>go innun chungida</i> (progressive verbal form)	+	-	+	+
Durative NP + <i>mane</i>	-	-	+	+
preparatory stage	+	-	+/-	+
Durative NP + <i>dongan</i>	+	+	+	+
Resultant state	-	-	-	+
	ACT	State	ACT_ACC	Ch_of_state

At last, the semantic term of the time adverbial and that of the nuclear sentence are joined together by the following rule to put the final semantic representation of (11)¹⁴:

ph1 → adv_DG, ph
 U1::tps2:dur & U2::(qu:no & multiocc:no)
 S0 <<= cond([[U2::asp:act/stat/act_acc,
 λQ.S2•(λE. (proj•1•S1)•E ∧ Q•E)],
 [U2::asp:ch_of_state, λQλR. S2•(λE.
 Q•E)•(λA. (proj•2•S1)•A ∧ R•A)]]).

Figure 4. *DONGAN* sentence construction rule

As we mentioned above, one of the most important advantages of G Grammar consists of its capacity to establish semantic interpretations in a compositional way. Even if we presented only the final step of semantic processing, our Korean parser constructs a semantic representation at each step¹⁵.

¹⁴ ‘/’ stands for disjunction.

‘λxλy. proj•x•y’ returns the member occurring in the x_{th} place in the list y.

¹⁵ Our Korean parser is built in LPI Prolog. In Figure 6, ‘1b’ stands for λ-abstraction and ‘*’ stands for λ-application.

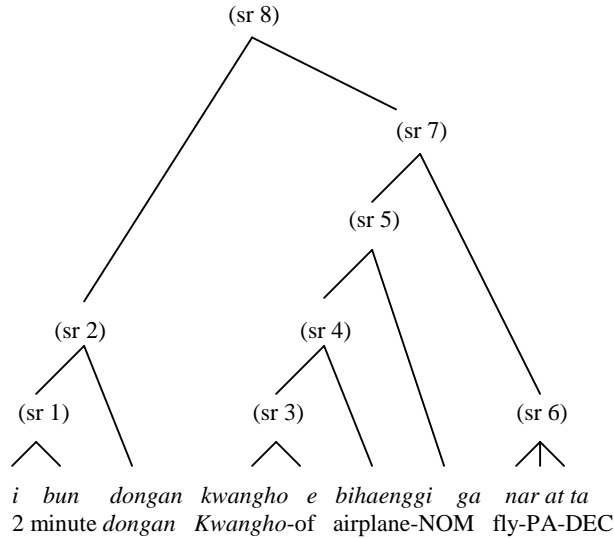


Figure 5. Parsing tree of the example (11)

```
(sr1) [0,0,0,2,0]
(sr2) lb(_24864,duration * _24864 =
[0,0,0,2,0] & ending * _24864 <
[2003,2,14,19,32])
(sr3) lb(_16476,lb(_15622,of *
kwangho * _15622 & _16476 * _15622))
(sr4) lb(_18330,exist * y * (of *
kwangho * y & airplane * y & _18330 *
y))
(sr5) lb(_18330,exist * y * (of *
kwangho * y & airplane * y & _18330 *
y))
(sr6) lb(_1682,lb(_1720,exist * e *
(fly * e * _1720 & beginning * e <
[2003,2,14,19,5] & _1682 * e)))
(sr7) lb(_4814,exist * y * (of *
kwangho * y & airplane * y & exist *
e * (fly * e * y & beginning * e <
[2003,2,14,19,7] & _4814 * e)))
(sr8) lb(_25184,exist * y * (of *
kwangho * y & airplane * y & exist *
e * (fly * e * y & beginning * e <
[2003,2,14,19,33] & (duration* e =
[0,0,0,2,0] & ending * e <
[2003,2,14,19,33] & _25184 * e))))
```

Figure 6. List of semantic representations presented in Figure 5.

The sentences extended by an *OE* adverbial are represented in the same way as those by a *DONGAN* adverbial, as will be seen in the following.

(8) *samwol shiboirOE nurôngoiga chugôtta.*
March/the fifteenth-*OE* /*Nurôngoi*-NOM/die-PA-DEC

On the fifteenth of March, *Nurôngoi* died.

Relying on the semantic and syntactic constraints of the phrase preceding *OE* at the same time, we determine the semantic term of the *OE* adverbial.

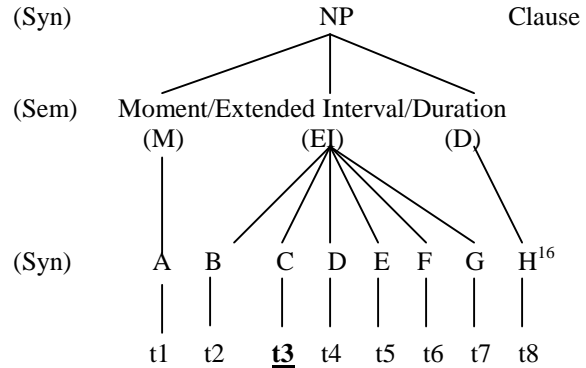


Figure 7. Processing of *OE* adverbials

Since *samwol shiboirOE* of (8) denotes an extended interval and it conforms to the syntactic condition C, this adverbial is attributed the semantic term of type t3.

The semantic representation of the nuclear sentence of (8) is established in the same way as explained above in Figure 3. At last, taking the semantic terms of the *OE* adverbial and of the nuclear sentence, the following rule serves to construct the final representation of the whole sentence¹⁷.

¹⁶ *OE* adverbials take the following syntactic structures:

- A. Instant NP + *OE*
- B. Interval Noun + *OE*
- C. Interval NP + *OE*
- D. Attributive Clause + Interval NP + *OE*
- E. Attributive Clause + Interval Noun + *OE*
- F. Deictic/anaphoric determiner + Interval NP + *OE*
- G. Deictic/anaphoric determiner + Interval Noun + *OE*
- H. Duration NP + *OE*

¹⁷ See [Son, 2002] for more detailed description of *OE*.

$ph1 \rightarrow adv_OE, ph$
 $U1::tps2:inter \ \& \ U2::(qu:no \ \& \ multiocc:no)$
 $S0 \ll= \text{cond}([U2::asp:ach1/ach2, \ \lambda Q. \ S2 \bullet (\lambda E. \text{proj} \bullet 1 \bullet S1) \bullet E \wedge Q \bullet E]),$
 $[U2::asp:acc, \ \lambda Q. \ S2 \bullet (\lambda E. \text{proj} \bullet 2 \bullet S1) \bullet E \wedge Q \bullet E]],$
 $[U2::asp:act/stat/act_acc/ch_of_state, \ \lambda Q. \ S2 \bullet (\lambda E. \text{proj} \bullet 3 \bullet S1) \bullet E \wedge Q \bullet E]])$

Figure 8. *OE* sentence construction rule

4 Conclusion

In this paper, we showed how *OE* adverbials and *DONGAN* adverbials contribute to constructing the temporal interpretation of Korean sentences. We also formalized the semantic properties of these temporal markers with typed lambda calculus before we integrated them into the Korean parser that we built on the basis of Renaud's G Grammar. We showed the effectiveness of this grammar in representing compositionally semantic interpretations of Korean sentences.

In the future, we will study the Korean time adverbials with *MANE* and zero particle. The first temporal marker is believed to signal the telicity of the event and the second appears very frequently in informal discourses.

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