Analyzing Time-Related Clauses in Transparent Intensional Logic

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Outline

Normal Translation Algorithm in TIL

- specification of translation from natural language sentences to constructions of Transparent Intensional Logic
- logical analysis based on syntactic rules
- describes analysis of all main linguistic phenomena
- the TIL project:
  - 2010 – analysis of simple sentences in past, present and future tense containing selected verbs
  - 2011 – analysis of relative time-related subordinate sentences
  - 2012 – analysis of complex sentences with temporal events including direct speech

Clause Analysis

verb phrase – the central point of each clause

1. attributive verbs

Zmíněné zařízení je číslicově řízené.

(The mentioned device is numerically controlled.)

$$\lambda w \lambda t (\exists i) \Big(\big[[\textbf{číslicově}_{wt}, \textbf{řízený}], i \big] \ \wedge \big[[\textbf{zmíněný}, \textbf{zařízení}]_{wt}, i \big] \Big) \ldots \pi$$

2. episodic verbs

Celková úmrtnost klesá.

(The overall mortality rate decreases.)

$$\lambda w_1 \lambda t_2 (\exists x_3)(\exists i_4) \Big(\big[\textbf{Does}_{w_1 t_2}, i_4, [\textbf{Imp}_{w_1}, x_3] \big] \ \wedge x_3 = \textbf{klesat}_{w_1} \ \wedge \big[[\textbf{celkový}, \textbf{úmrtnost}]_{w_1 t_2}, i_4 \big] \Big) \ldots \pi$$

Verb Tense

verb tense = operation working over

1. the underlying proposition in the present tense form and
2. the reference time span
3. with regard to an assertion moment

P/F/$(o(o(o\tau))(o\tau))\tau$ ... past/future tense

$$\mathbf{P}\Big(\text{<frequency adverb>}\big(\text{<proposition>}\big),\ \text{<reference time span>}\Big)$$

Verb Tense Example

Celní správa vyžadovala originální certifikát.
(Customs administration required an original certificate.)

$$\lambda w_1 \lambda t_2 \Big[\mathbf{P}_{t_2}, \Big[\mathbf{Onc}_{w_1}, \lambda w_3 \lambda t_4 (\exists x_5)(\exists i_6)(\exists i_7) \Big(\big[\mathbf{Does}_{w_3 t_4}, i_7, [\mathbf{Imp}_{w_3}, x_5] \big] \wedge$$

$$\wedge \ \big[[\mathbf{originální}, \mathbf{certifikát}]_{w_3 t_4}, i_6 \big] \ \wedge \ x_5 = [\mathbf{vyžadovat}, i_6]_{w_3} \ \wedge$$

$$\wedge \big[[\mathbf{celní}, \mathbf{správa}]_{w_3 t_4}, i_7 \big] \Big) \Big], \mathbf{Anytime} \Big] \ldots \pi$$

Complex Sentences

sentence schemata:

- connected with syntactic rules which connect a clause with a (possible complex) sentence
- describes analysis based on conjunctions

Petr včera přišel, když Markéta telefonovala babičce.
(Petr came yesterday, when Markéta phoned her grandmother.)

když (when/if) can have two readings:

1. the temporal when
2. the implication if

The logical analysis offers ambiguously both readings.

Complex Sentences Analysis

Petr včera přišel (Petr came yesterday): `time span TIL:`
$\lambda t_1 \mathbf{včera}_{tt_1} \ldots (o\tau)$ `frequency TIL:` $\mathbf{Onc} \ldots ((o(o\tau))\pi)_\omega$
`verbal object TIL:` $x_1/(o(o\pi)(o\pi)) = \mathbf{přijít}_w \ldots o$ `clause TIL:`

$$\lambda w_1 \lambda t_2 \left[\mathbf{P}_{t_2}, \left[\mathbf{Onc}_{w_1}, \lambda w_3 \lambda t_4 (\exists x_5) \Big(\left[\mathbf{Does}_{w_3 t_4}, Petr, [\mathbf{Perf}_{w_3}, x_5] \right] \wedge x_5 = \mathbf{přijít}_{w_3} \Big) \right], \lambda t_7 \mathbf{včera}_{t_2 t_7} \right] \ldots \pi$$

Complex Sentences Analysis

Markéta telefonovala babičce (Markéta phoned her grandmother):

`time span TIL:` $\mathbf{Anytime}\ldots(o\tau)$ `frequency TIL:`
$\mathbf{Onc}\ldots((o(o\tau))\pi)_\omega$ `verbal object TIL:`
$x_1/(o(o\pi)(o\pi)) = [\mathbf{telefonovat}, i_2]_w \wedge \quad \wedge [\mathbf{babička}_{wt}, i_2]\ldots o$

`clause TIL:` $\lambda w_1 \lambda t_2 \Big[\mathbf{P}_{t_2}, \Big[\mathbf{Onc}_{w_1}, \lambda w_3 \lambda t_4 (\exists x_5)(\exists i_6)(\exists i_7)\Big($

$\big[\mathbf{Does}_{w_3 t_4}, \mathit{Markéta}, [\mathbf{Perf}_{w_3}, x_5]\big] \quad \wedge \quad [\mathbf{babička}_{w_3 t_4}, i_6] \quad \wedge$

$\wedge\, x_5 = [\mathbf{telefonovat}, i_6]_{w_3}\Big)\Big], \mathbf{Anytime}\Big]\ldots\pi$

Complex Sentences Analysis

the corresponding sentence schema is looked up in the lexicon:

```
sentence_rule_schema: schema = S1 'když' S2
reading #1: lwt(tense_temp(awt(#1),awt(#2)))
```

The first reading (when):

- adverbial temporal clause
- use the clause's construction directly as a generator of a collection of the time moments where the clause's extension is True
- the subordinate clause is used as a generator of the reference time span – a characteristic function of a class of time moments ($\lambda t_0[\dots]$)

Complex Sentences Analysis

Thus the original main clauses reference time span $\lambda t_7 \mathbf{včera}_{tt_7}$ is replaced with

$$\lambda t_1 \Big(\mathbf{včera}_{tt_2} \wedge \Big[\mathbf{P}_t, \Big[\mathbf{Onc}_w, \lambda w_5 \lambda t_6 (\exists x_7)(\exists i_8)(\exists i_9) \Big(\Big[\mathbf{Does}_{w_5 t_6}, \mathit{Markéta}, \quad \ldots \quad \Big) \Big], \lambda t_7 (t_7 = t_1) \Big] \Big] \Big) \ldots ((o\tau)\tau)$$

Complex Sentences Analysis

The resulting analysis of the whole sentence in the first (temporal) reading looks like

$$\lambda w_1 \lambda t_2 \Big[\mathbf{P}_{t_2}, \Big[\mathbf{Onc}_{w_1}, \lambda w_5 \lambda t_6 (\exists x_7) \Big(\big[\mathbf{Does}_{w_5 t_6}, \mathit{Petr}, [\mathbf{Perf}_{w_5}, x_7] \big] \wedge$$

$$\wedge\, x_7 = \mathbf{přijít}_{w_5} \Big) \Big], \lambda t_9 \Big(\mathbf{včera}_{t_2 t_9} \;\wedge\; \Big[\mathbf{P}_{t_2}, \Big[\mathbf{Onc}_{w_1},$$

$$\lambda w_{13} \lambda t_{14} (\exists x_{15}) (\exists i_{16}) \Big(\big[\mathbf{Does}_{w_{13} t_{14}}, \mathit{Markéta}, [\mathbf{Perf}_{w_{13}}, x_{15}] \big] \wedge$$

$$[\mathbf{babička}_{w_{13} t_{14}}, i_{16}] \;\wedge\; x_{15} =$$

$$[\mathbf{telefonovat}, i_{16}]_{w_{13}} \Big) \Big], \lambda t_{18} (t_{18} = t_9) \Big] \Big) \Big] \ldots \pi$$

Complex Sentences Analysis

The second reading of the example sentence:

```
reading #2:
lwt([awt(O(když/(((o((ot)w)((ot)w))t)w))),#1,#2])
Schema trivialization TIL: když...(oππ)τω
```

Complex Sentences Analysis

$$\lambda w_1 \lambda t_2 \Big[\mathbf{když}_{w_1 t_2}, \lambda w_3 \lambda t_4 \Big[\mathbf{P}_{t_4}, \Big[\mathbf{Onc}_{w_3}, \lambda w_5 \lambda t_6 (\exists x_7) \Big(\Big[\mathbf{Does}_{w_5 t_6}, \mathit{Petr}, [\mathbf{Perf}_{w_5}, x_7] \Big] \wedge x_7 = \mathbf{přijít}_{w_5} \Big) \Big], \lambda t_9 \mathbf{včera}_{t_4 t_9} \Big],$$

$$\lambda w_{10} \lambda t_{11} \Big[\mathbf{P}_{t_{11}}, \Big[\mathbf{Onc}_{w_{10}}, \lambda w_{12} \lambda t_{13} (\exists x_{14}) (\exists i_{15}) \Big(\Big[\mathbf{Does}_{w_{12} t_{13}}, \mathit{Markéta}, [\mathbf{Perf}_{w_{12}}, x_{14}] \Big] \wedge [\mathbf{babička}_{w_{12} t_{13}}, i_{15}] \wedge x_{14} = [\mathbf{telefonovat}, i_{15}]_{w_{12}} \Big) \Big], \mathbf{Anytime} \Big] \Big] \ldots \pi$$