On LR Parsing with Selective Delays

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CC 2013, March 22nd

Rome, Italy

Selective ML

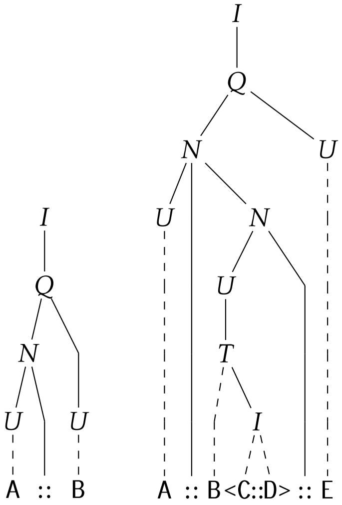
named after Marcus (1980) and Leermakers (1992)

C++ Qualified Identifiers

(ISO Standard, 1998)

Grammar:

$$
\begin{aligned}
I &\to U \mid Q \\
U &\to i \mid T \\
Q &\to N\,U \\
N &\to U :: N \mid U :: \\
T &\to i<I>
\end{aligned}
$$



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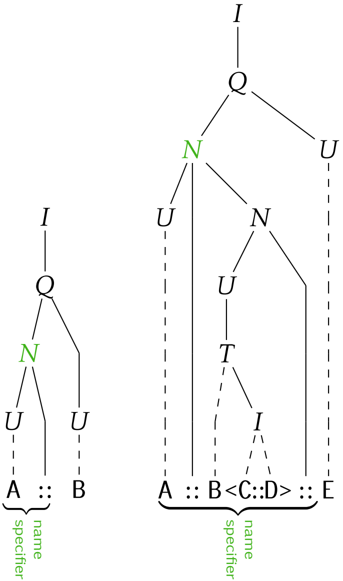

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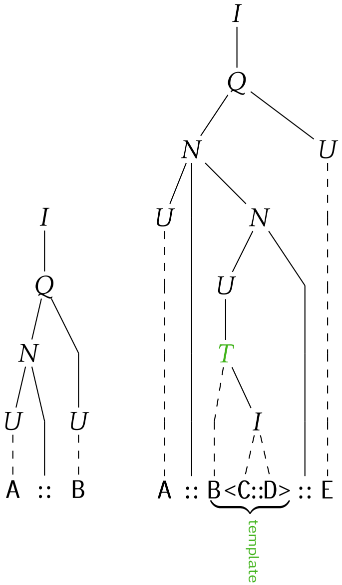

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GNU/Bison output:

- `conflicts: 1 shift/reduce`
- `warning: rule useless in parser due to conflicts:`

$$N \to U ::$$

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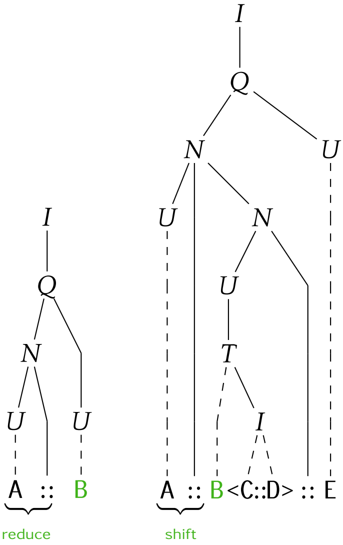

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Solutions?

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- priority mechanisms
  (Bouwers et al., 2008)
- GLR
- refactor the grammar
  - language-preserving
  - large space of possible transformations
    (see e.g. Lämmel, 2001)

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left-recursive Grammar:

$$I \rightarrow U \mid Q$$
$$U \rightarrow i \mid T$$
$$Q \rightarrow N\,U$$
$$N \rightarrow N\,U :: \mid U ::$$
$$T \rightarrow i <I>$$

Solutions?

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C++ Qualified Identifiers

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combed Grammar:

$$I \rightarrow U \mid Q$$
$$U \rightarrow i \mid T$$
$$Q \rightarrow [NU]$$
$$N \rightarrow U :: N \mid U ::$$
$$T \rightarrow i<I>$$

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$$[NU] \rightarrow U :: [NU] \mid U :: U$$
$$T \rightarrow i \lt I \gt$$

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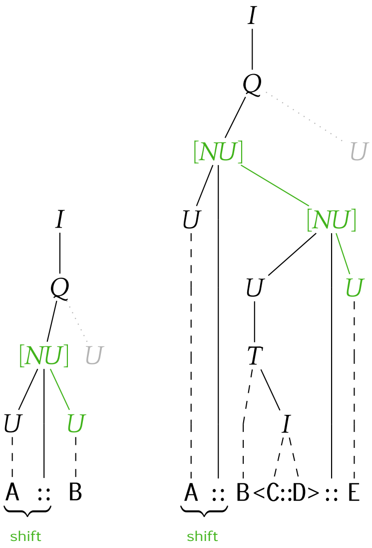


Going Formal: Combings

Write a context-free grammar as $G = \langle N, \Sigma, P, S \rangle$, with vocabulary $V = \Sigma \uplus N$.

$G \hookrightarrow G'$ if $\exists \mu : V'^* \to V^*$ a homomorphism s.t.

1. $\mu(S') = S$,
2. $\forall a \in \Sigma, \mu(a) = a$,
3. $\mu(N') \subseteq N \cdot V^*$
4. $\{A' \to \mu(\alpha') \mid A' \to \alpha' \in P'\}$
   $= \{A' \to \alpha\delta \mid A' \in N', \mu(A') = A\delta$, and $A \to \alpha \in P\}$

We call it a k-combing ($\hookrightarrow_k$) if $\mu(N') \subseteq N \cdot V^{\leqslant k}$.

Going Formal: Combings

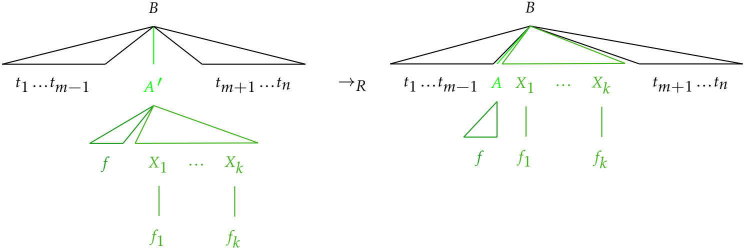
Example

$$
\begin{array}{rl@{\qquad}rl}
I & \to U \mid Q & I & \to U \mid Q \\
U & \to i \mid T & U & \to i \mid T \\
Q & \to NU & Q & \to [NU] \\
N & \to U :: N \mid U :: & [NU] & \to U :: [NU] \mid U :: U \\
T & \to i < I > & T & \to i < I >
\end{array}
$$

Define $\mu([NU]) = N\,U$ and $\mu(A) = A$ for the other nonterminals A.

(Un-)Combings as Tree Mappings

One rule per nonterminal A' s.t. $\mu(A') = A X_1 \cdots X_q$:



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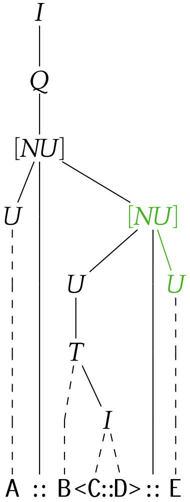

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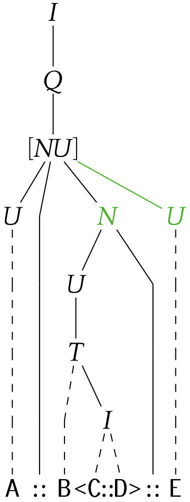

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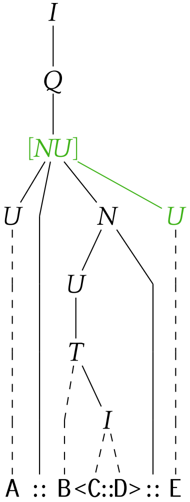

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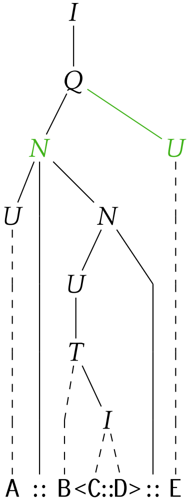

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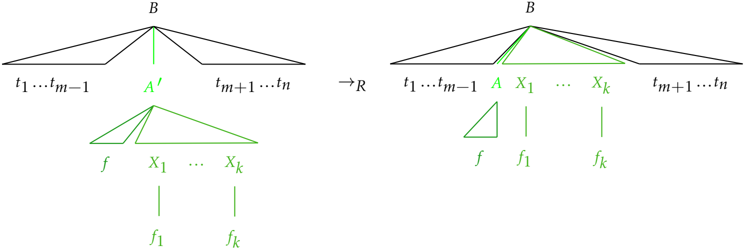
One rule per nonterminal A' s.t.
$\mu(A') = AX_1 \cdots X_q$:



Formally, a forest rewriting system, which is confluent, terminating, and preserves terminal yields:

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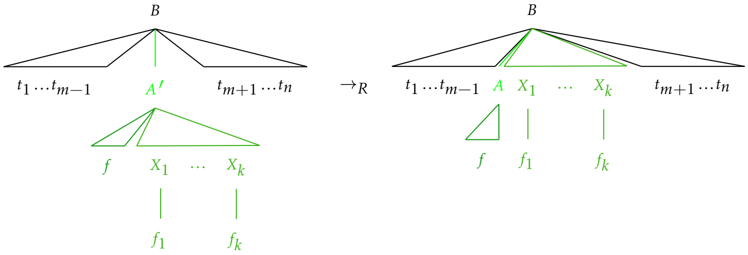

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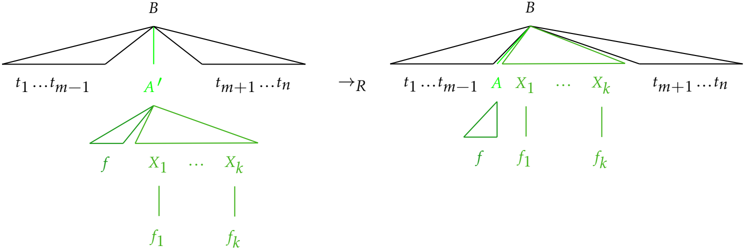

Formally, a forest rewriting system, which is confluent, terminating, and preserves terminal yields:

Theorem

If $G \hookrightarrow G'$, *then* $L(G) = L(G')$.

Selective ML

Definition

G is selML(k, m) if $\exists G', G\#^k \hookrightarrow_k G'$ and G' is LR(m).

Combing Strategies

Given k:

- always comb "as much context as possible"?
  ML(k,m) grammars (Bertsch and Nederhof, 2007)
- always comb "as little as possible"?

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SelML(k,m) parsers

Principles

- LR-like construction
- add context only when required
- recompute states in case of conflicts: distinguished conflict and deprecated items.
- a combing can be extracted from the parser

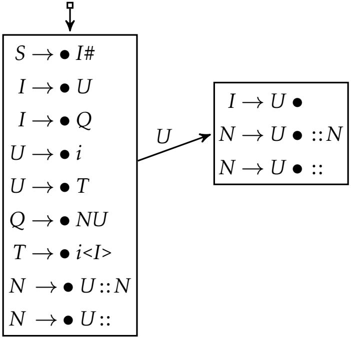
SelML(k,m) parsers

Example

$S \to \bullet\ I\#$
$I \to \bullet\ U$
$I \to \bullet\ Q$
$U \to \bullet\ i$
$U \to \bullet\ T$
$Q \to \bullet\ NU$
$T \to \bullet\ i{<}I{>}$
$N \to \bullet\ U::N$
$N \to \bullet\ U::$

SELML(k,m) PARSERS

EXAMPLE



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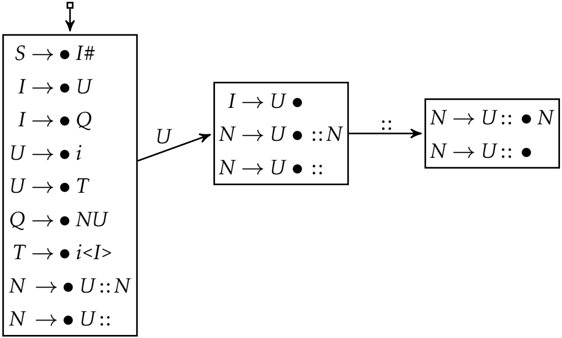

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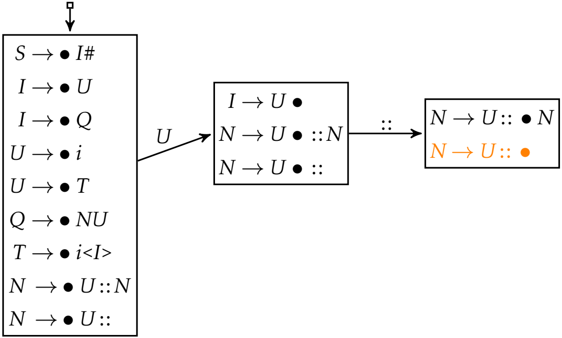

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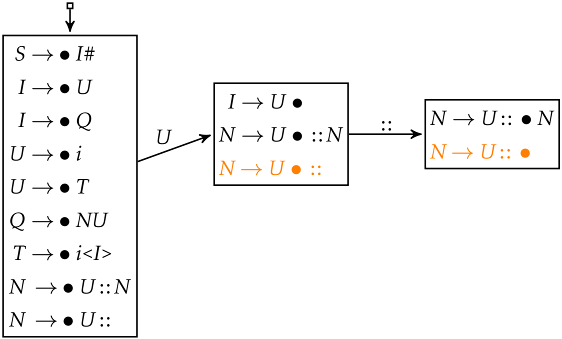

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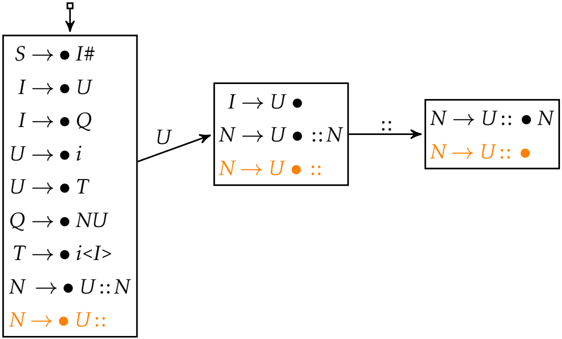

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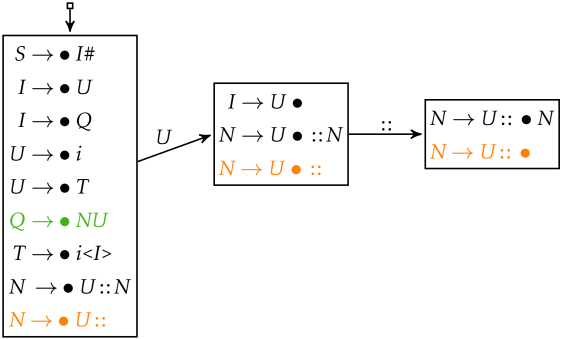

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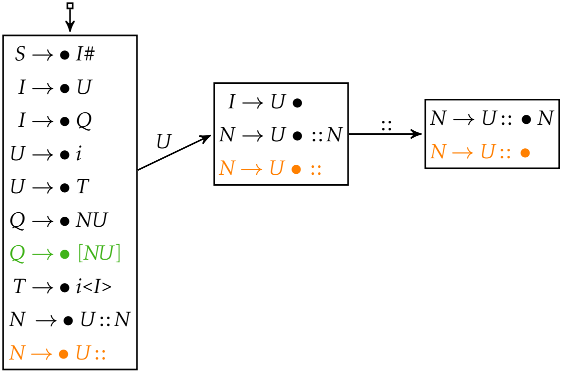

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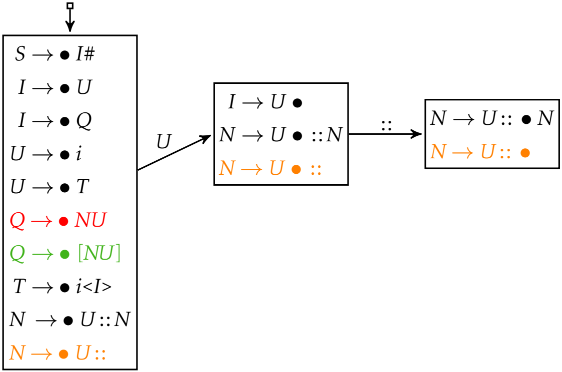

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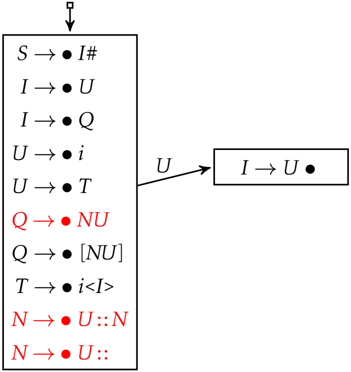

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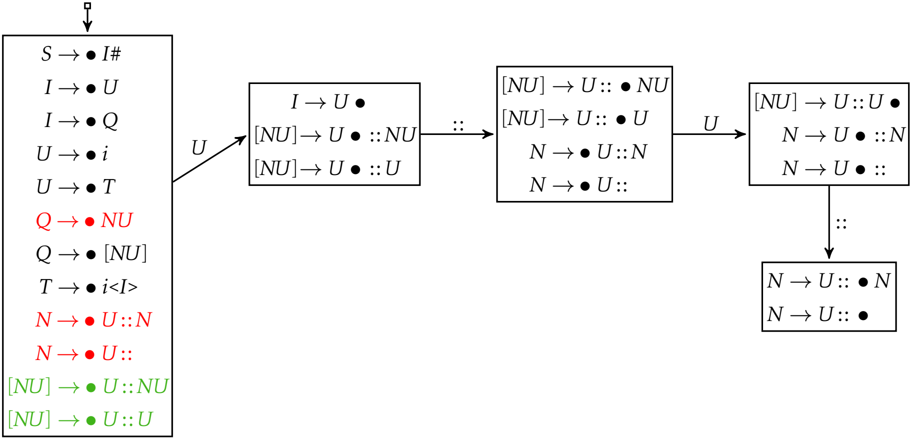

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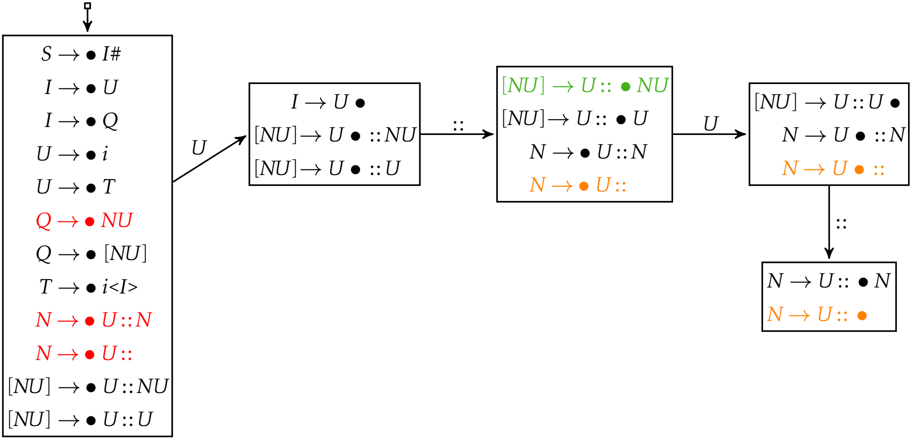

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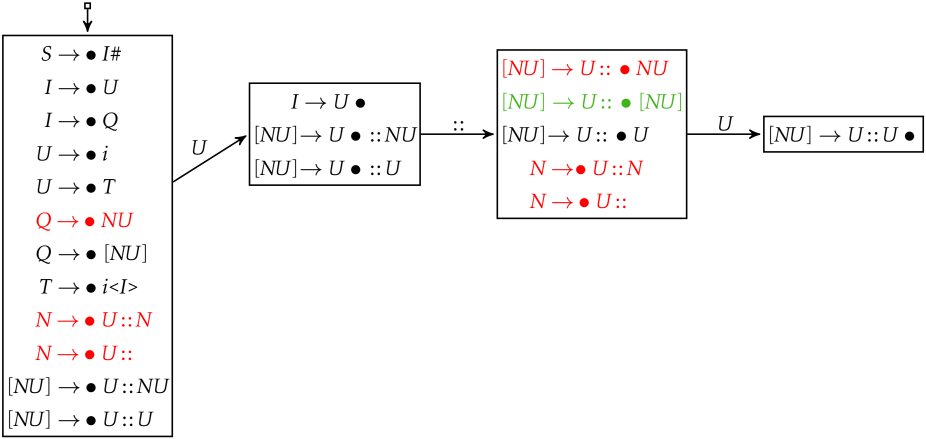

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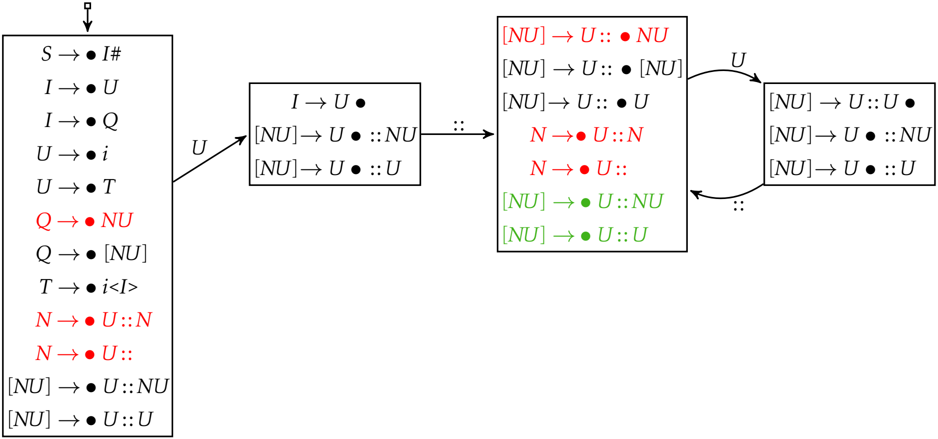

Theoretical Results

For each k and m:

grammar class selML(k,m) includes ML(k,m), and thus LR(m)

monotonicity selML(k,m) implies selML(k',m') for all $k' \geqslant k$ and $m' \geqslant m$

unambiguity of selML grammars

deterministic the language of a selML grammar is a DCFL

undecidability of whether a grammar is selML(k,m) for some k and m

Experimental Results

- proof of concept implementation available at http://www.cs.st-andrews.ac.uk/~mjn/code/mlparsing/
- grammar classes on 26 small grammars (Basten, 2008; Schmitz, 2010), $k + m \leqslant 50$:

- parser sizes:
  - often much smaller than ML
  - inconclusive wrt. LR

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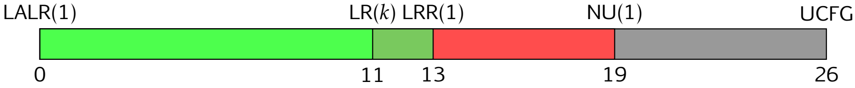

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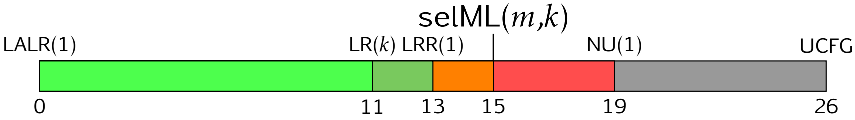

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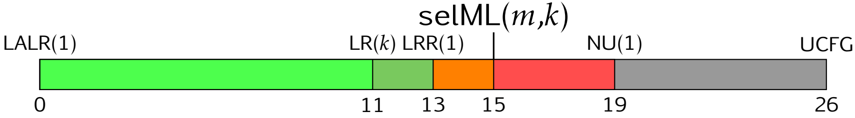

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Concluding Remarks

- avoid (some) LR conflicts
- deterministic parsing: linear-time complexity and exclusion of ambiguities
- grammar transformation view
- LR-like parser: can be used for generalized parsing.

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