Extended Context-Free Grammars Parsing with Generalized LL

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Chapter 18. Syntax

This chapter presents a grammar for the Java programming language.

The grammar presented piecemeal in the preceding chapters (§2.3) is much better for exposition, but it is not well suited as a basis for a parser. The grammar presented in this chapter is the basis for the reference implementation. Note that it is not an LL(1) grammar, though in many cases it minimizes the necessary look ahead.

The grammar below uses the following BNF-style conventions:

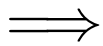
- *[x]* denotes zero or one occurrences of *x*.
- *{x}* denotes zero or more occurrences of *x*.
- *(x | y)* means one of either *x* or *y*.

```
Identifier:
    IDENTIFIER
QualifiedIdentifier:
    Identifier { . Identifier }
QualifiedIdentifierList:
    QualifiedIdentifier { , QualifiedIdentifier }
```

Extended Context-Free Grammar

$$
\begin{aligned}
S &= a\ M^* \\
M &= a?\ (B\ K)^+ \\
&\quad \mid u\ B \\
B &= c \mid \varepsilon
\end{aligned}
$$

```
ident: IDENTIFIER
qualiId: ident {DOT ident}
qualifiedIdList: qualiId {COMMA qualiId}
compilationUnit:
    [[Annotations] Package qualiId SEMI]
    {importDecl} {typeDecl}
importDecl: Import [Static] ident
    {DOT ident} [DOT STAR] SEMI
typeDecl: classOrInterfaceDecl SEMI
classOrInterfaceDecl:
    {Modifier} (ClassDecl | InterfaceDecl)
```



```
ident: IDENTIFIER
qualiId: ident many_1
many_1:
    | ident many_1
qualifiedIdList: qualiId many_2
many_2:
    | COMMA qualiId many_2
compilationUnit: opt_1 many_3 many_4
opt_2:
    | Annotations
opt_1:
    | opt_2 Package qualiId SEMI
many_3:
    | importDecl many_3
many_4:
    | typeDecl many_4
importDecl:
    Import opt_3 ident many_5 opt_4 SEMI
opt_3:
    | Static
many_5:
    | DOT ident many_5
opt_4:
    | DOT STAR
typeDecl: classOrInterfaceDecl SEMI
alt_1: ClassDecl | InterfaceDecl
classOrInterfaceDecl:
    many_6 alt_1
many_6:
    | Modifier many_6
```

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Existing solutions

- ANTLR, Yacc, Bison

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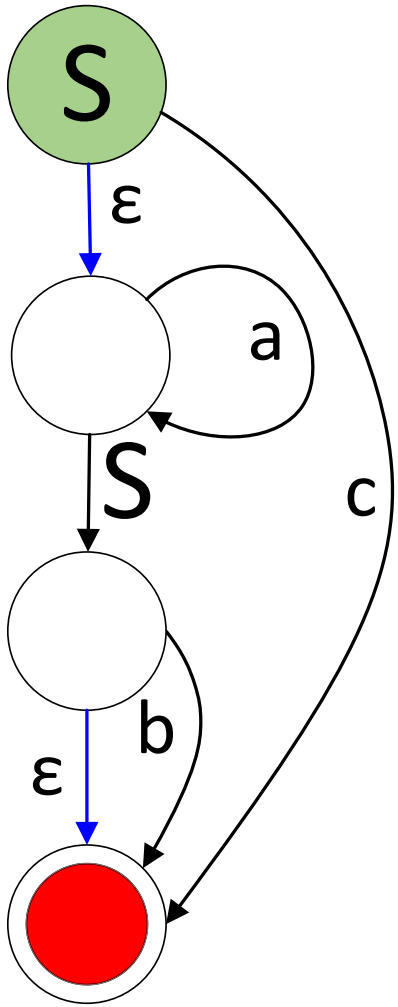
Automata and ECFGs

Grammar G_0

$$S = a^* S\ b? \mid c$$

$\Longrightarrow$

RA for grammar G_0

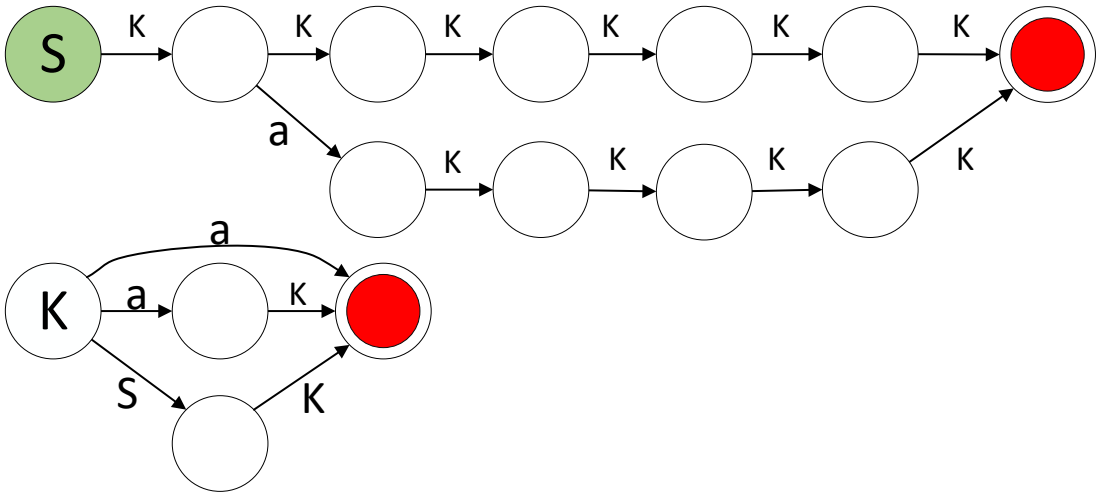


Recursive Automata Minimization

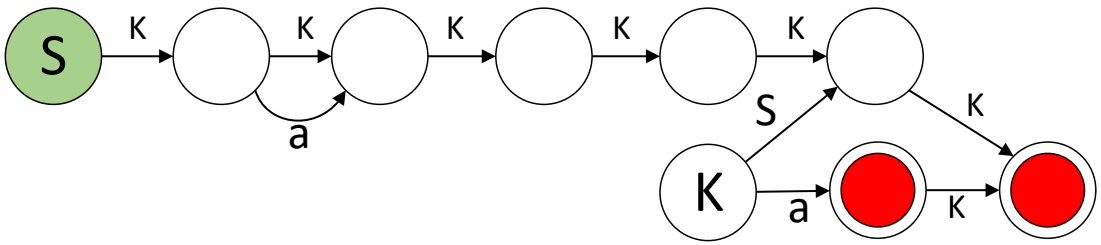
Grammar G_1

$$S = K\ K\ K\ K\ K\ K \mid K\ a\ K\ K\ K\ K$$
$$K = S\ K \mid a\ K \mid a$$

Automaton for G_1



Minimized automaton for G_1

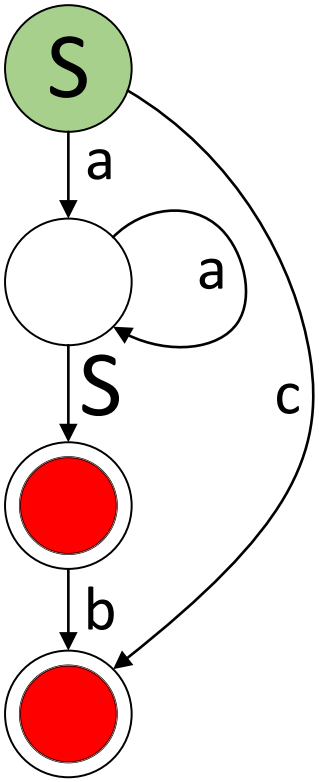


Derivation Trees for Recursive Automata

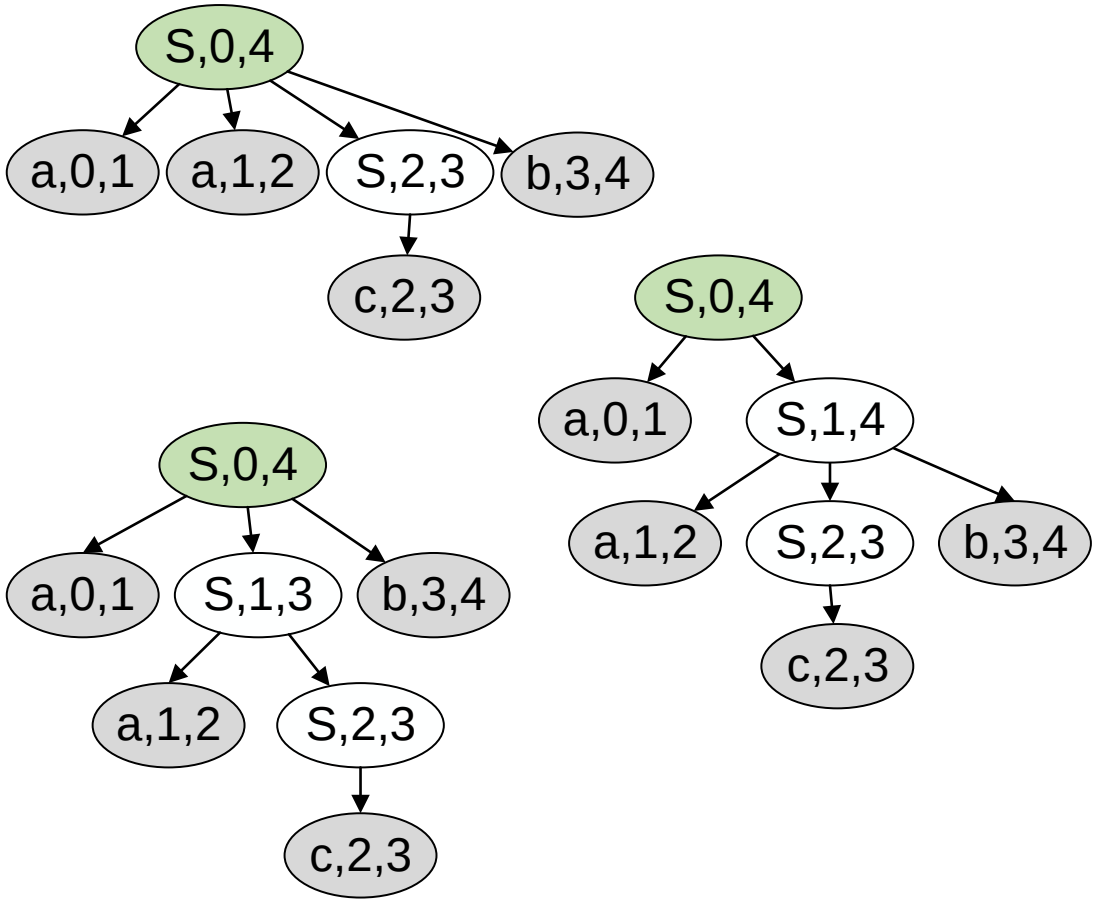
Input:

aacb

Automaton:



Derivation trees:

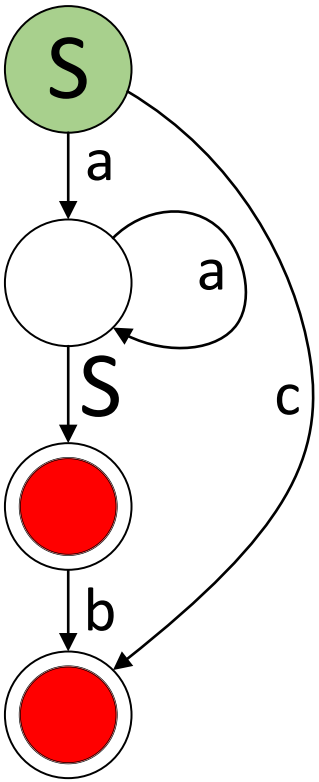


SPPF for Recursive Automata

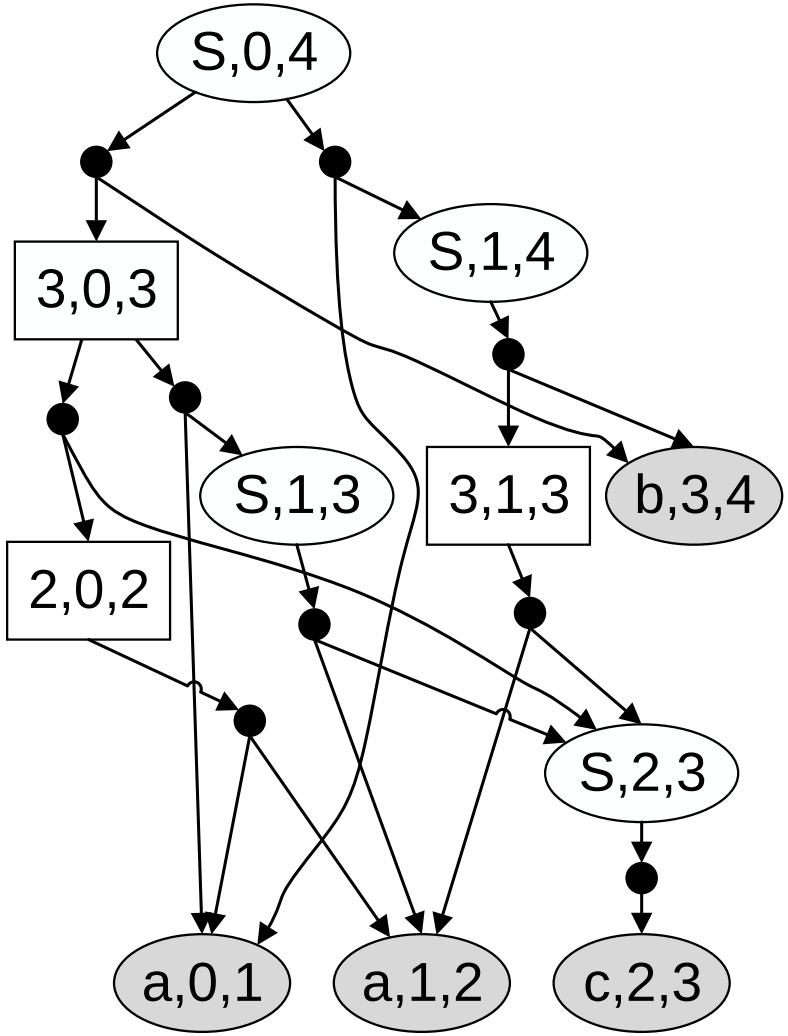
Input:

aacb

Automaton:



Shared Packed Parse Forest:



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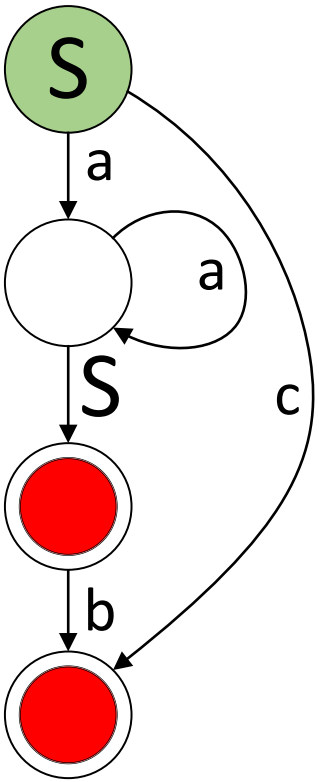

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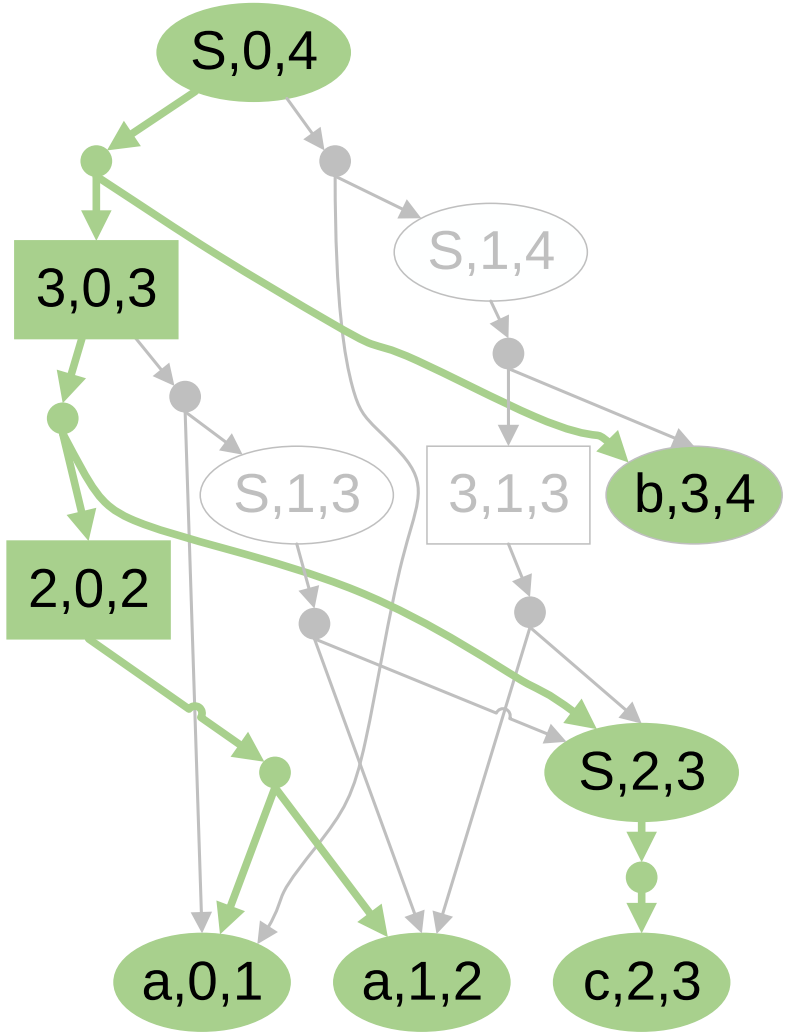

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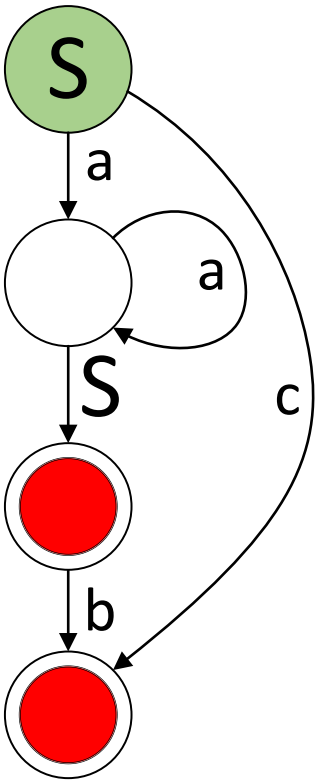

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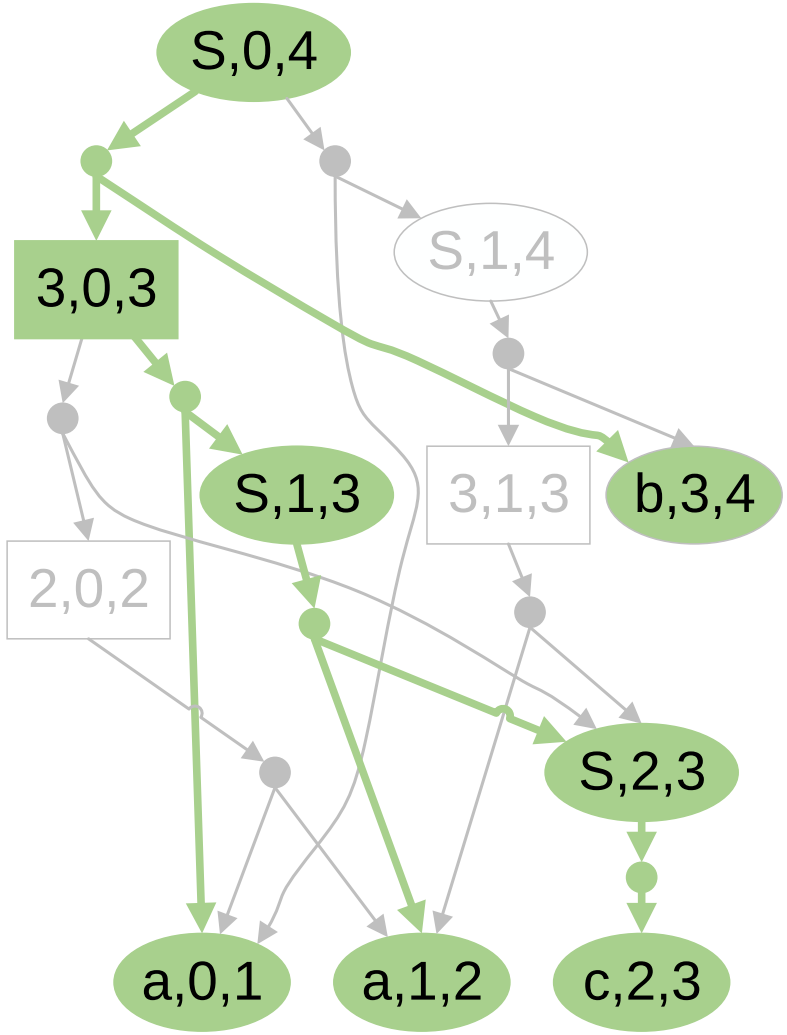

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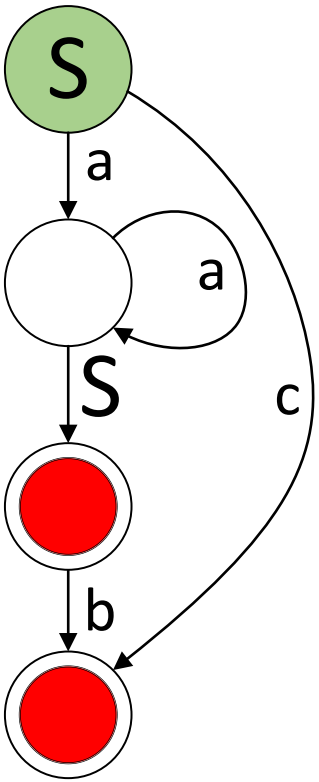

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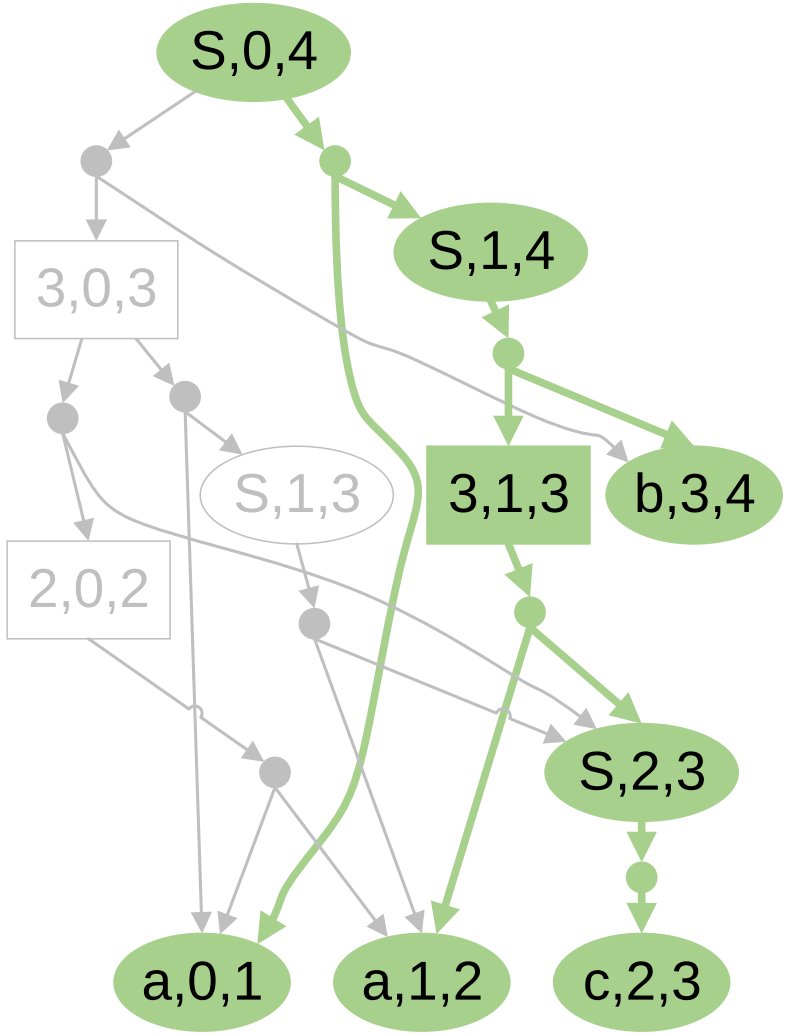

Input processing

- Descriptors queue
- Descriptor (G, i, U, T) uniquely defines parsing process state
  - G - position in grammar
  - i - position in input
  - U - stack node
  - T - current parse forest root

Input processing

- Descriptors queue
- Descriptor (G, i, U, T) uniquely defines parsing process state
  - G - ~~position in grammar~~ state of RA
  - i - position in input
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Input processing

Input : bc

Grammar:

$$S = (a \mid b \mid S)\ c?$$

Input processing

Input : bc

Grammar:

$$\begin{aligned} S &= a\ C\_opt \\ &\mid b\ C\_opt \\ &\mid S\ C\_opt \\ C\_opt &= \varepsilon \mid c \end{aligned}$$

Input processing

Input : $\bullet\ bc$

Grammar:

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Descriptors queue

$S = \bullet\ a\ C\_opt,\ 0,\ \ldots,\ \ldots$

Input processing

Input : $\bullet\ bc$

Grammar:

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Descriptors queue

$$\begin{array}{|c|}\hline S = \bullet\ b\ C\_opt,\ 0,\ \ldots,\ \ldots \\ \hline S = \bullet\ a\ C\_opt,\ 0,\ \ldots,\ \ldots \\ \hline \end{array}$$

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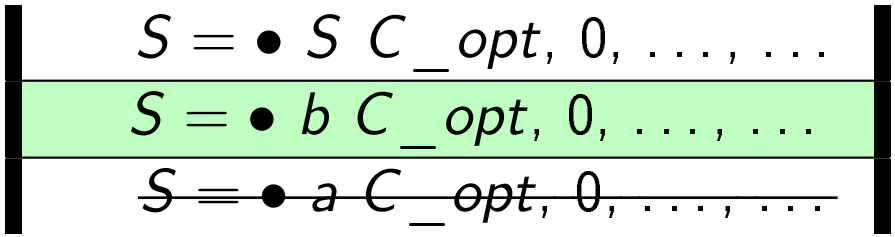


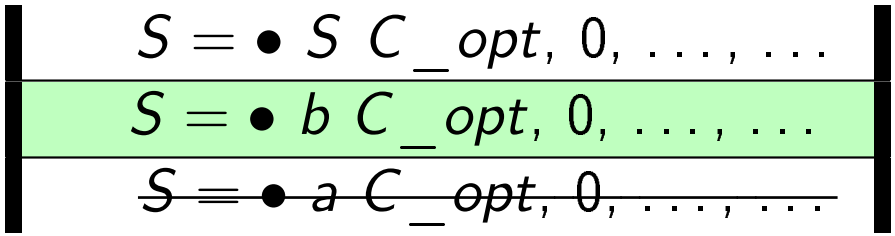
Input processing

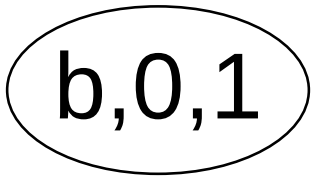
Input : $b \bullet c$

Grammar:

$$\begin{aligned} S &= a\ C\_opt \\ &\mid b \bullet\ C\_opt \\ &\mid S\ C\_opt \\ C\_opt &= \varepsilon \mid c \end{aligned}$$

Descriptors queue





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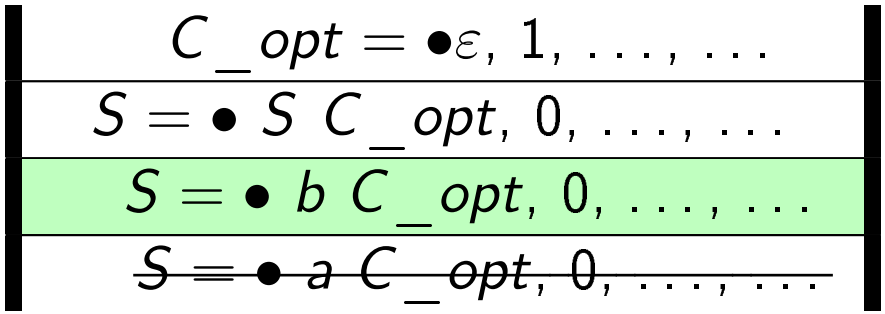

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Descriptors queue

$C\_opt = \bullet c,\ 1, \ldots, \ldots$
$C\_opt = \bullet \varepsilon,\ 1, \ldots, \ldots$
$S = \bullet\ S\ C\_opt,\ 0, \ldots, \ldots$
$S = \bullet\ b\ C\_opt,\ 0, \ldots, \ldots$
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Input : $b \bullet c$

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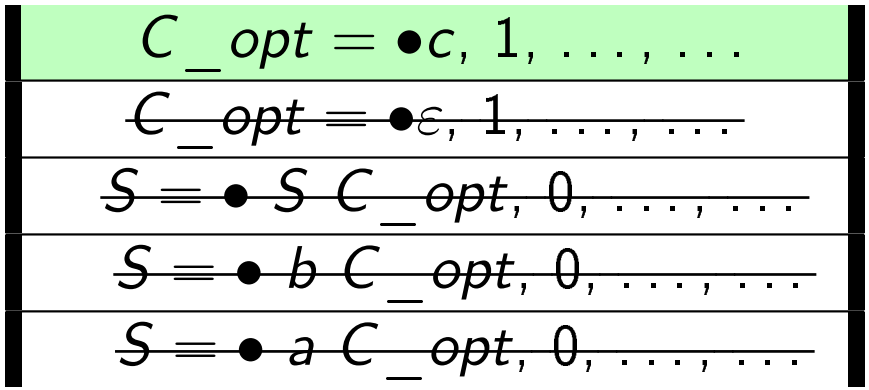

Input processing

Input : $bc\bullet$

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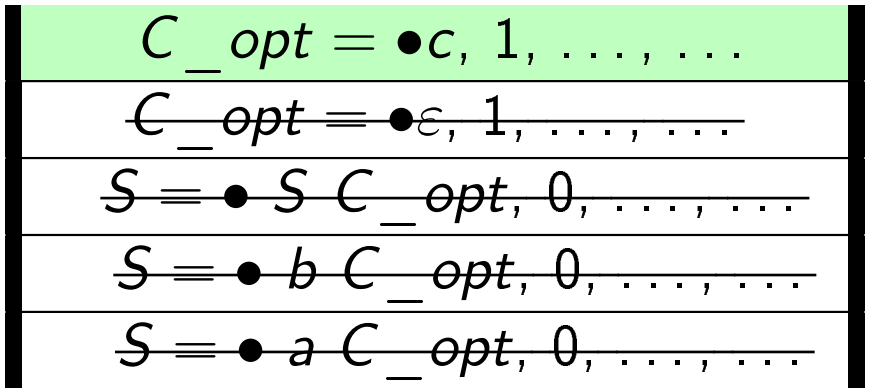
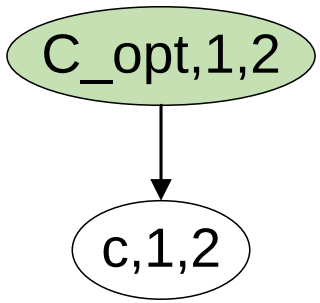
Descriptors queue

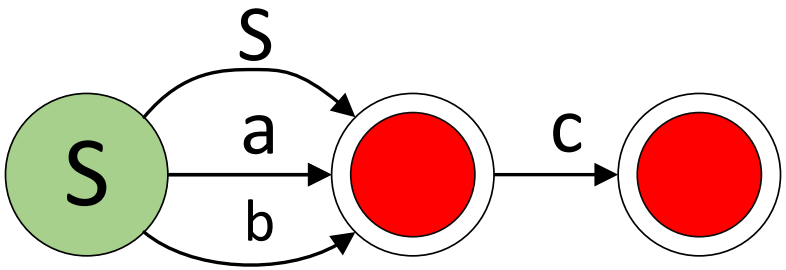




Input processing

Input : bc

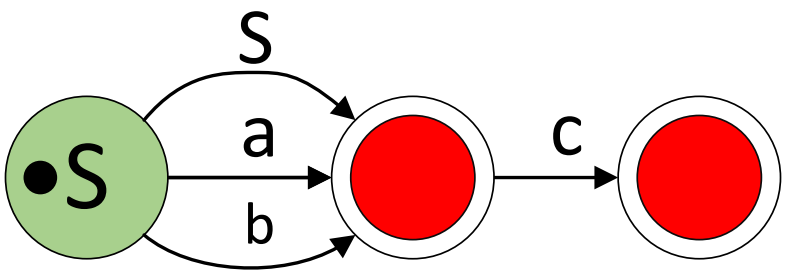
Automaton :



Input processing

Input : • bc

Automaton :



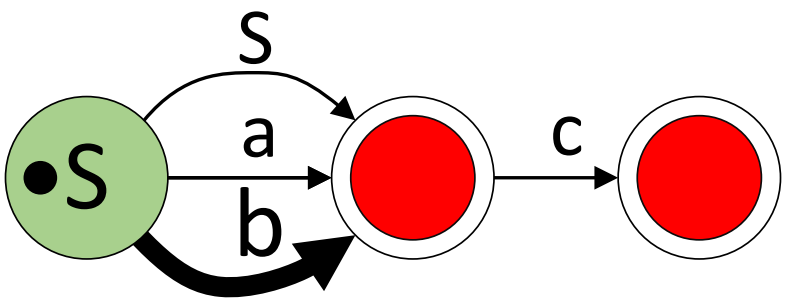
Descriptors queue

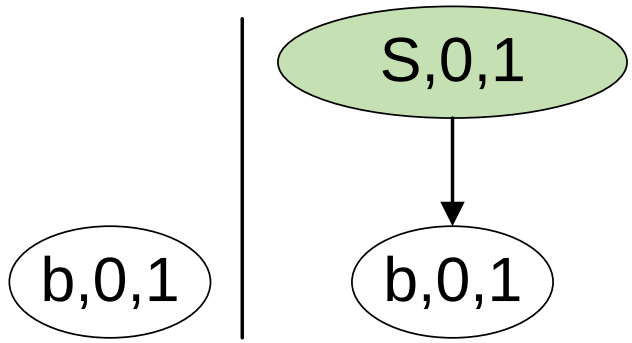
$S, 0, \ldots, \ldots$

Input processing

Input : • *bc*

Automaton :



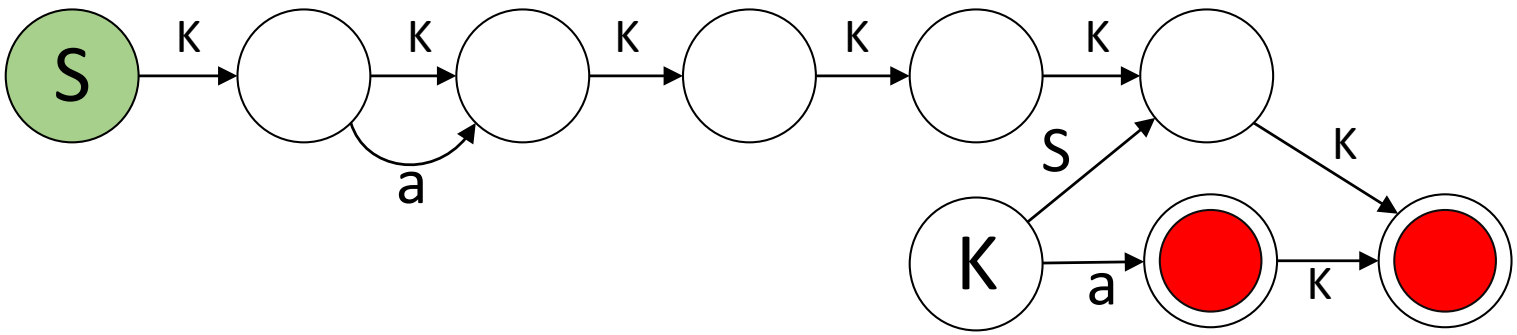


Evaluation

Grammar G_1

$$S = K\ K\ K\ K\ K\ K \mid K\ a\ K\ K\ K\ K$$
$$K = S\ K \mid a\ K \mid a$$

RA for grammar G_1



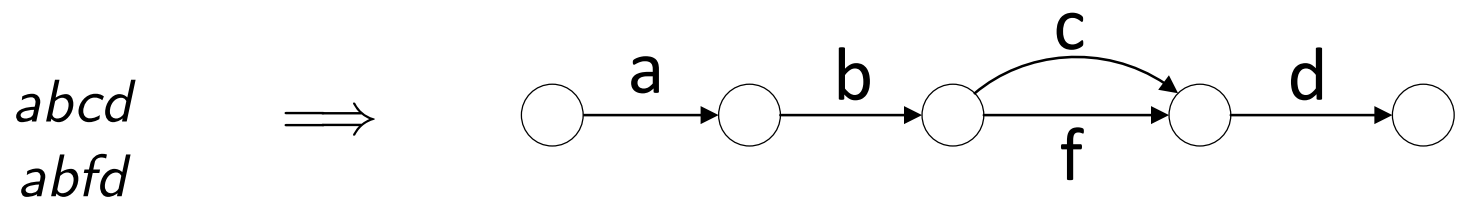
Experiment results for input a^{40}

	Memory usage			Time,sec
	Descriptors	Stack Edges	SPPF Nodes	
Grammar	7,940	6,974	111,127,244	81
RA	5,830	4,234	74,292,078	54
Ratio	27%	39%	33 %	35 %

Applicability

Graph parsing: all input strings in one graph

abcd
abfd



Graph parsing results

	Memory usage			Time, min
	Descriptors	Stack Edges	Stack Nodes	
Grammar	21,134,080	7,482,789	2,731,529	02.26
RA	9,153,352	2,792,330	839,148	01.25
Ratio	57%	63%	69 %	45 %