Problem Language

```
grammar Problem
   nonterminal S(0), A(2), B(2);
               a(2), b(2), c(2), d(2), e(2);
   terminal
   start
                S;
   S()
            ::= A(b,c) b(c,d) B(d,e) e(e,f) [s]
            ::= /* eps */
   A(a,c)
                                             [a1]
            | B(a,b) c(b,c)
                                             [a2]
   B(a,b)
           ::= /* eps */
                                             [b1]
             | d(a,b)
                                             [b2]
end
```

[a1]

[b1]

State $q_0(a, b, c, d, e)$ $\mathsf{S}() \longrightarrow \mathsf{A}(\boldsymbol{a}, \boldsymbol{b}) \,\mathsf{b}(\boldsymbol{b}, \boldsymbol{c}) \,\mathsf{B}(\boldsymbol{c}, \boldsymbol{d}) \,\mathsf{e}(\boldsymbol{d}, \boldsymbol{e})$ $\mathsf{A}(\boldsymbol{a},\boldsymbol{b}) \to \mathbf{.}$ $\mathsf{A}(\boldsymbol{a},\boldsymbol{b}) \ \ o \mathbf{L} \mathsf{B}(\boldsymbol{a},n_1) \, \mathsf{c}(n_1,\boldsymbol{b})$ $\mathsf{B}(\boldsymbol{a},n_2) \rightarrow \mathbf{.}$ $\mathsf{B}(\boldsymbol{a},n_3) \rightarrow \mathsf{Ld}(\boldsymbol{a},n_3)$ $\mathsf{A}(n_0,n_1)$ $\xrightarrow{n_0, n_0, n_1, \dots, n_1} q_4(n_0, n_1, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e})$ $\mathsf{B}(n_0,n_1)$ $n_0 = \boldsymbol{a}, n_1 = ?$ $q_2(n_0, \boldsymbol{b})$ $\begin{array}{c} \underbrace{n_0} & a, n_1 \end{array} \\ \hline n_0 = a, n_1 \uparrow \end{array} \rightarrow q_3(n_0, b, n_1)$ $\mathsf{B}(n_0,n_1)$ $\mathsf{d}(n_0, n_1)$ $\longrightarrow q_1(n_0, n_1)$ $n_0 = \boldsymbol{a}, n_1 \uparrow$ State $q_1(a, b)$ [b2] $\mathsf{B}(\boldsymbol{a},\boldsymbol{b}) \to \mathsf{d}(\boldsymbol{a},\boldsymbol{b})$. State $q_2(a, b)$ $\mathsf{A}(\boldsymbol{a},\boldsymbol{b})
ightarrow \mathsf{B}(\boldsymbol{a},n_1)$. $\mathsf{c}(n_1,\boldsymbol{b})$

$$\xrightarrow{ \ \ \mathbf{c}(n_0,n_1) } n_0 \uparrow, n_1 = \mathbf{b} \rightarrow q_5(\mathbf{a},n_1,n_0)$$

 $\begin{array}{c} \textbf{State} \ \boldsymbol{q_3}(\boldsymbol{a},\boldsymbol{b},\boldsymbol{c}) \\ \hline \mathsf{A}(\boldsymbol{a},\boldsymbol{b}) \rightarrow \mathsf{B}(\boldsymbol{a},\boldsymbol{c}) \boldsymbol{\textbf{.}} \mathsf{c}(\boldsymbol{c},\boldsymbol{b}) \end{array}$

$$\begin{array}{c} \mathbf{c}(n_0, n_1) \\ \hline n_0 = \mathbf{c}, n_1 = \mathbf{b} \end{array} \qquad q_5(\mathbf{a}, n_1, n_0)$$

State $q_4(a, b, c, d, e)$

$$S() \rightarrow A(a, b) \cdot b(b, c) B(c, d) e(d, e)$$

$$\frac{\mathbf{b}(n_0, n_1)}{n_0 = \mathbf{b}, n_1 = \mathbf{c}} \rightarrow q_6(\mathbf{a}, n_0, n_1, \mathbf{d}, \mathbf{e})$$

 $\begin{array}{c} \textbf{State } q_5(a,b,c) \\ \hline \textbf{A}(a,b) \rightarrow \textbf{B}(a,c) \, \textbf{c}(c,b) \, \textbf{.} \quad [a2] \end{array}$

 $\begin{array}{c} \textbf{State } q_{6}(a, b, c, d, e) \\ \hline \texttt{S}() & \rightarrow \texttt{A}(a, b) \texttt{b}(b, c) \textbf{.} \texttt{B}(c, d) \texttt{e}(d, e) \\ \hline \texttt{B}(c, d) & \rightarrow \textbf{.} \\ \texttt{B}(c, d) & \rightarrow \textbf{.} \\ \texttt{B}(c, d) & \rightarrow \textbf{.} \texttt{d}(c, d) \end{array}$

 $\begin{array}{c} \underline{\mathsf{B}}(n_0,n_1) \\ \hline n_0 = \boldsymbol{c}, n_1 = \boldsymbol{d} \end{array} \rightarrow q_7(\boldsymbol{a}, \boldsymbol{b}, n_0, n_1, \boldsymbol{e}) \\ \underline{\mathsf{d}}(n_0,n_1) \\ \hline n_0 = \boldsymbol{c}, n_1 = \boldsymbol{d} \end{array} \rightarrow q_1(n_0,n_1)$

 $\begin{array}{l} \textbf{State } \boldsymbol{q_7}(\boldsymbol{a}, \boldsymbol{b}, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e}) \\ \hline \textbf{S}() \rightarrow \textbf{A}(\boldsymbol{a}, \boldsymbol{b}) \, \textbf{b}(\boldsymbol{b}, \boldsymbol{c}) \, \textbf{B}(\boldsymbol{c}, \boldsymbol{d}) \textbf{.} \, \textbf{e}(\boldsymbol{d}, \boldsymbol{e}) \end{array}$

$$\xrightarrow{\mathbf{e}(n_0, n_1)} n_0 = \mathbf{d}, n_1 = \mathbf{e} \rightarrow q_8(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_0, n_1)$$

 $\begin{array}{l} \textbf{State } \boldsymbol{q_8}(\boldsymbol{a}, \boldsymbol{b}, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e}) \\ \hline \textbf{S}() \rightarrow \textbf{A}(\boldsymbol{a}, \boldsymbol{b}) \, \textbf{b}(\boldsymbol{b}, \boldsymbol{c}) \, \textbf{B}(\boldsymbol{c}, \boldsymbol{d}) \, \textbf{e}(\boldsymbol{d}, \boldsymbol{e}) \, \textbf{.} \quad [s] \end{array} \end{array}$

Super-clean Problem Language

```
grammar Problem_superclean
   nonterminal Z(0), S(5), A(2), B(2);
                a(2), b(2), c(2), d(2), e(2);
   terminal
   start
                Z;
   Z()
                ::= S(b,c,d,e,f)
                                                  [z]
   S(b,c,d,e,f) ::= A(b,c) b(c,d) B(d,e) e(e,f)
                                                  [s1]
                 | A(b,c) b(c,d) e(e,f)
                                                  [s2]
                 | b(c,d) B(d,e) e(e,f)
                                                  [s3]
                                                  [s4]
                 | b(c,d) e(e,f)
   A(a,c)
                ::= B(a,b) c(b,c)
                                                  [a1]
                 | c(b,c)
                                                  [a2]
   B(a,b)
                ::= d(a,b)
                                                  [Ъ]
end
```

State $q_0(a, b, c, d, e)$

$\begin{array}{l} A(a,b) & \to \cdot B(a,n_1) c(n_1,b) \\ A(a,b) & \to \cdot c(n_2,b) \\ B(a,n_3) & \to \cdot d(a,n_3) \\ S(a,b,c,d,e) & \to \cdot A(a,b) b(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) & \to \cdot A(a,b) b(b,c) e(d,e) \\ S(a,b,c,d,e) & \to \cdot b(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) & \to \cdot b(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) & \to \cdot b(b,c) B(c,d) e(d,e) \\ \end{array}$	Z()	$ ightarrow$. S $(oldsymbol{a},oldsymbol{b},oldsymbol{c},oldsymbol{d},oldsymbol{e})$
$\begin{array}{l} A(a,b) & \to \mathbf{.c}(n_2,b) \\ B(a,n_3) & \to \mathbf{.d}(a,n_3) \\ S(a,b,c,d,e) & \to \mathbf{.A}(a,b) b(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) & \to \mathbf{.A}(a,b) b(b,c) e(d,e) \\ S(a,b,c,d,e) & \to \mathbf{.b}(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) & \to \mathbf{.b}(b,c) B(c,d) e(d,e) \\ \end{array}$	$A(\boldsymbol{a},\boldsymbol{b})$	$ ightarrow \mathbf{B}(oldsymbol{a},n_1)\mathbf{c}(n_1,oldsymbol{b})$
$\begin{array}{l} B(a,n_3) \longrightarrow d(a,n_3) \\ S(a,b,c,d,e) \rightarrow A(a,b) b(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) \rightarrow A(a,b) b(b,c) e(d,e) \\ S(a,b,c,d,e) \rightarrow A(a,b) b(b,c) e(d,e) \\ S(a,b,c,d,e) \rightarrow b(b,c) B(c,d) e(d,e) \\ \end{array}$	$A(oldsymbol{a},oldsymbol{b})$	$ ightarrow$. c $(n_2,oldsymbol{b})$
$\begin{array}{c} S(a,b,c,d,e) \to A(a,b) b(b,c) B(c,d) e(d,e) \\ S(a,b,c,d,e) \to A(a,b) b(b,c) e(d,e) \\ S(a,b,c,d,e) \to b(b,c) B(c,d) e(d,e) \\ \end{array}$	$B(\boldsymbol{a},n_3)$	$ ightarrow$. d $(oldsymbol{a},n_3)$
$S(a, b, c, d, e) \rightarrow A(a, b) b(b, c) e(d, e)$ $S(a, b, c, d, e) \rightarrow b(b, c) B(c, d) e(d, e)$ $S(a, b, c, d, e) \rightarrow b(b, c) B(c, d) e(d, e)$	S(a, b, c, d, e)	$ ightarrow$. A $(m{a},m{b})$ b $(m{b},m{c})$ B $(m{c},m{d})$ e $(m{d},m{e})$
$S(a, b, c, d, e) \rightarrow b(b, c) B(c, d) e(d, e)$ $S(a, b, c, d, c) \rightarrow b(b, c) g(d, c)$	S(a, b, c, d, e)	$ ightarrow$. A $(oldsymbol{a},oldsymbol{b})$ b $(oldsymbol{b},oldsymbol{c})$ e $(oldsymbol{d},oldsymbol{e})$
$S(a b a d a) \rightarrow b(b a) a(d a)$	S(a, b, c, d, e)	$ ightarrow$. b $(m{b},m{c})$ B $(m{c},m{d})$ e $(m{d},m{e})$
$\mathbf{J}(\boldsymbol{u},\boldsymbol{v},\boldsymbol{c},\boldsymbol{u},\boldsymbol{e}) \rightarrow \mathbf{I} \mathbf{J}(\boldsymbol{v},\boldsymbol{c}) \mathbf{e}(\boldsymbol{u},\boldsymbol{e})$	S(a, b, c, d, e)	$ ightarrow$. b $(m{b},m{c})$ e $(m{d},m{e})$

 $A(n_0, n_1)$ $\longrightarrow q_7(n_0, n_1, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e}, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e})$ $n_0 = \boldsymbol{a}, n_1 = \boldsymbol{b}$ $\mathsf{B}(n_0, n_1)$ $\rightarrow q_6(n_0, \boldsymbol{b}, n_1)$ $n_0 = \boldsymbol{a}, n_1 \uparrow$ $S(n_0, n_1, n_2, n_3, n_4)$ $n_0 = a, n_1 = b, n_2 = c, n_3 = d, n_4 = e \rightarrow q_5(n_0, n_1, n_2, n_3, n_4)$ $b(n_0, n_1)$ $\rightarrow q_1(\boldsymbol{a}, n_0, n_1, \boldsymbol{d}, \boldsymbol{e}, \boldsymbol{a}, \boldsymbol{d}, \boldsymbol{e})$ $n_0 = \boldsymbol{b}, n_1 = \boldsymbol{c}$ $c(n_0, n_1)$ $\rightarrow q_3(\boldsymbol{a}, n_1, n_0)$ $n_0\uparrow, n_1 = \boldsymbol{b}$ $d(n_0, n_1)$ $\rightarrow q_2(n_0, n_1)$ $n_0 = \boldsymbol{a}, n_1 \uparrow$

State $q_1(a, b, c, d, e, a, d, e)$ $\mathsf{S}(\boldsymbol{a}, \boldsymbol{b}, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e})
ightarrow \mathsf{b}(\boldsymbol{b}, \boldsymbol{c})$. $\mathsf{e}(\boldsymbol{d}, \boldsymbol{e})$ $\mathsf{S}({m{a}},{m{b}},{m{c}},{m{d}},{m{e}}) o \mathsf{b}({m{b}},{m{c}})$. $\mathsf{B}({m{c}},{m{d}})\,\mathsf{e}({m{d}},{m{e}})$ $ightarrow extsf{a} \mathsf{d}(m{c},m{d})$ $\mathsf{B}(\boldsymbol{c},\boldsymbol{d})$ $B(n_0, n_1)$ $n_0 = c, n_1 = d \rightarrow q_8(a, b, n_0, n_1, e)$ $\frac{\mathsf{d}(n_0, n_1)}{n_0 = \boldsymbol{c}, n_1 = \boldsymbol{d}} \to q_2(n_0, n_1)$ $n_0 = \boldsymbol{d}, n_1 = \boldsymbol{e}$ $q_4(\boldsymbol{a}, \boldsymbol{b}, \boldsymbol{c}, n_0, n_1)$ $e(n_0, n_1)$ State $q_2(a, b)$ [b] $\mathsf{B}(\boldsymbol{a},\boldsymbol{b}) \to \mathsf{d}(\boldsymbol{a},\boldsymbol{b})$. State $q_3(a, b, c)$ $\mathsf{A}(\boldsymbol{a},\boldsymbol{b})
ightarrow \mathsf{c}(\boldsymbol{c},\boldsymbol{b})$. a2State $q_4(a, b, c, d, e)$ $\mathsf{S}(oldsymbol{a},oldsymbol{b},oldsymbol{c},oldsymbol{d},oldsymbol{e}) o \mathsf{b}(oldsymbol{b},oldsymbol{c})\,\mathsf{e}(oldsymbol{d},oldsymbol{e})$. [s4]State $q_5(a, b, c, d, e)$ $| \mathsf{Z}() \rightarrow \mathsf{S}(\boldsymbol{a}, \boldsymbol{b}, \boldsymbol{c}, \boldsymbol{d}, \boldsymbol{e}).$ [z]State $q_6(a, b, c)$

 $\mathsf{A}(a,b) o \mathsf{B}(a,c) \cdot \mathsf{c}(c,b)$

$$\begin{array}{c} \mathsf{c}(n_0, n_1) \\ \hline n_0 = \boldsymbol{c}, n_1 = \boldsymbol{b} \end{array} q_9(\boldsymbol{a}, n_1, n_0)$$

State $q_7(a, b, c, d, e, c, d, e)$ $S(a, b, c, d, e) \rightarrow A(a, b)$. b(b, c) B(c, d) e(d, e) $\mathsf{S}(\boldsymbol{a},\boldsymbol{b},\boldsymbol{c},\boldsymbol{d},\boldsymbol{e})
ightarrow \mathsf{A}(\boldsymbol{a},\boldsymbol{b})$. $\mathsf{b}(\boldsymbol{b},\boldsymbol{c})\,\mathsf{e}(\boldsymbol{d},\boldsymbol{e})$ $\frac{\mathsf{b}(n_0,n_1)}{n_0=\boldsymbol{b},n_1=\boldsymbol{c}} \not q_{10}(\boldsymbol{a},n_0,n_1,\boldsymbol{d},\boldsymbol{e},\boldsymbol{d},\boldsymbol{e})$ State $q_8(a, b, c, d, e)$ $\mathsf{S}({m a},{m b},{m c},{m d},{m e}) o \mathsf{b}({m b},{m c})\,\mathsf{B}({m c},{m d})$. $\mathsf{e}({m d},{m e})$ $\begin{array}{c} \underline{\mathbf{e}(n_0,n_1)} \\ n_0 = \underline{\mathbf{d}}, n_1 = \underline{\mathbf{e}} \end{array} \rightarrow q_{11}(\underline{\mathbf{a}}, \underline{\mathbf{b}}, \underline{\mathbf{c}}, n_0, n_1) \end{array}$ State $q_9(a, b, c)$ $\mathsf{A}(\boldsymbol{a},\boldsymbol{b})
ightarrow \mathsf{B}(\boldsymbol{a},\boldsymbol{c}) \, \mathsf{c}(\boldsymbol{c},\boldsymbol{b})$. [a1]State $q_{10}(a, b, c, d, e, f, g)$ $\mathsf{S}(\boldsymbol{a},\boldsymbol{b},\boldsymbol{c},\boldsymbol{d},\boldsymbol{e})
ightarrow \mathsf{A}(\boldsymbol{a},\boldsymbol{b}) \, \mathsf{b}(\boldsymbol{b},\boldsymbol{c})$. $\mathsf{e}(\boldsymbol{d},\boldsymbol{e})$ $\mathsf{S}(\pmb{a},\pmb{b},\pmb{c},\pmb{f},\pmb{g})\to \underline{\mathsf{A}}(\pmb{a},\pmb{b})\,\mathsf{b}(\pmb{b},\pmb{c})$. $\mathsf{B}(\pmb{c},\pmb{f})\,\mathsf{e}(\pmb{f},\pmb{g})$ $ightarrow extsf{a} \mathsf{d}(m{c},m{f})$ $\mathsf{B}(\boldsymbol{c},\boldsymbol{f})$ $\frac{\mathsf{B}(n_0,n_1)}{n_0=\boldsymbol{c},n_1=\boldsymbol{f}} \to q_{12}(\boldsymbol{a},\boldsymbol{b},n_0,n_1,\boldsymbol{g})$ $\mathsf{d}(n_0,n_1)$ $\begin{array}{c} \underbrace{\mathbf{e}(n_0,n_1)}{n_0=\mathbf{d},n_1=\mathbf{e}} & q_{13}(\mathbf{a},\mathbf{b},\mathbf{c},n_0,n_1) \end{array}$ State $q_{11}(a, b, c, d, e)$ $igsim \mathsf{S}(oldsymbol{a},oldsymbol{b},oldsymbol{c},oldsymbol{d},oldsymbol{e}) \, \mathsf{B}(oldsymbol{c},oldsymbol{d}) \, \mathsf{e}(oldsymbol{d},oldsymbol{e})$. [s3]State $q_{12}(a, b, c, d, e)$

 $S(a, b, c, d, e) \rightarrow A(a, b) b(b, c) B(c, d) \cdot e(d, e)$

$$\xrightarrow{\mathbf{e}(n_0, n_1)} n_0 = \mathbf{d}, n_1 = \mathbf{e} \rightarrow q_{14}(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_0, n_1)$$

 $\begin{array}{l} \textbf{State } q_{13}(a,b,c,d,e) \\ \hline \textbf{S}(a,b,c,d,e) \rightarrow \textbf{A}(a,b) \, \textbf{b}(b,c) \, \textbf{e}(d,e) \, \textbf{.} \quad [s \textbf{2}] \end{array} \right|$

 $\begin{array}{c} \text{State } q_{14}(a,b,c,d,e) \\ \hline \left[\begin{array}{c} \mathsf{S}(a,b,c,d,e) \to \mathsf{A}(a,b) \, \mathsf{b}(b,c) \, \mathsf{B}(c,d) \, \mathsf{e}(d,e) \, \boldsymbol{.} \end{array} \right] \end{array}$