Let $G = (N, T, P, S)$ be a cfg.

Def. *$[A \rightarrow \alpha\bullet\beta]$ is called as an LR(0) item, if $A \rightarrow \alpha\beta \in P$.$\in$*

Let $I_G = \{[A \rightarrow \alpha\bullet\beta] \mid A \rightarrow \alpha\beta \in P\}$ be set of LR(0) items of G.

Def. *An **augmented** grammar of $G = (N, T, P, S)$ is*

$$G' = (N \cup \{S'\}, T, P \cup \{S' \rightarrow S\}, S') \text{ where } S' \notin N.$$

Fact, *$L(G) = L(G')$*

Def. *The **rule automaton** for an augmented cfg $G = (N, T, P, S)$ is an ε-NFA $R_G = (I_G, N \cup T, \rightarrow_R, [S' \rightarrow \bullet S], \{[S' \rightarrow S\bullet]\})$ where*

$([A \rightarrow \alpha\bullet X\gamma], X) \rightarrow_R ([A \rightarrow \alpha X\bullet\gamma], \varepsilon)$ for $X \in N \cup T$, $\alpha, \gamma \in (N \cup T)^*$,

$([A \rightarrow \alpha\bullet B\gamma], \varepsilon) \rightarrow_R ([B \rightarrow \bullet\beta], \varepsilon)$ for $B \in N$, $\alpha, \gamma \in (N \cup T)^*$ $B\rightarrow\beta \in P$.

Def. *A DFA of the ε-NFA R_G is $D_G = (2^{I_G}, N \cup T, \rightarrow_D, \varepsilon^*([S' \rightarrow \bullet S]), \varepsilon^*([S' \rightarrow S\bullet])$ where $(\varepsilon^*(\{[A \rightarrow \alpha\bullet X\gamma]\}), X) \rightarrow_D (\varepsilon^*(\{[A \rightarrow \alpha X\bullet\gamma]\}), \varepsilon)$.*

Alg*. Collection** *of* ***set of *LR(0)* ***items***(*LR(0)* ***states***): $C_0 \subseteq 2^{I_G}$.

$C_0 := \{\varepsilon^*([S' \to \bullet S])\}$ /* = [ε] */

repaeat

  for $q \in C_0$ ***do***

    for $[\{[A \to \alpha \bullet X\gamma]\} \in q$ ***do*** *where* $X \in N \cup T$ /* $q = [\alpha^R\delta^R]$ */

     $p := \varepsilon^*(\{[A \to \alpha X \bullet \gamma]\})$ /* $p = [X\alpha^R\delta^R]$ */

     if $X \in T \to$ ***shift***$(q, X) = p \mid X \in N \to$ ***goto***$(q, X) = p$ ***fi***

     $C_0 := C_0 \cup \{q\}$

  od od

until C_0 *does not increase*

Kernel and non kernel items of in LR(0) states $p \in C_0$

  K_P: *Kernel items* $[A \to \alpha \bullet \beta] \in p$, *if* $(A = S') \vee (\alpha \neq \varepsilon)$.

  $p = \varepsilon^*(K_P) = K_P \cup \varepsilon^+(K_P)$.   *Kernel items* $\cup$ *Non kernel items*

Two ***actions*** *in LR(0) right parser(PDA) with* ***configuration*** $T^* \times C_0^*$.

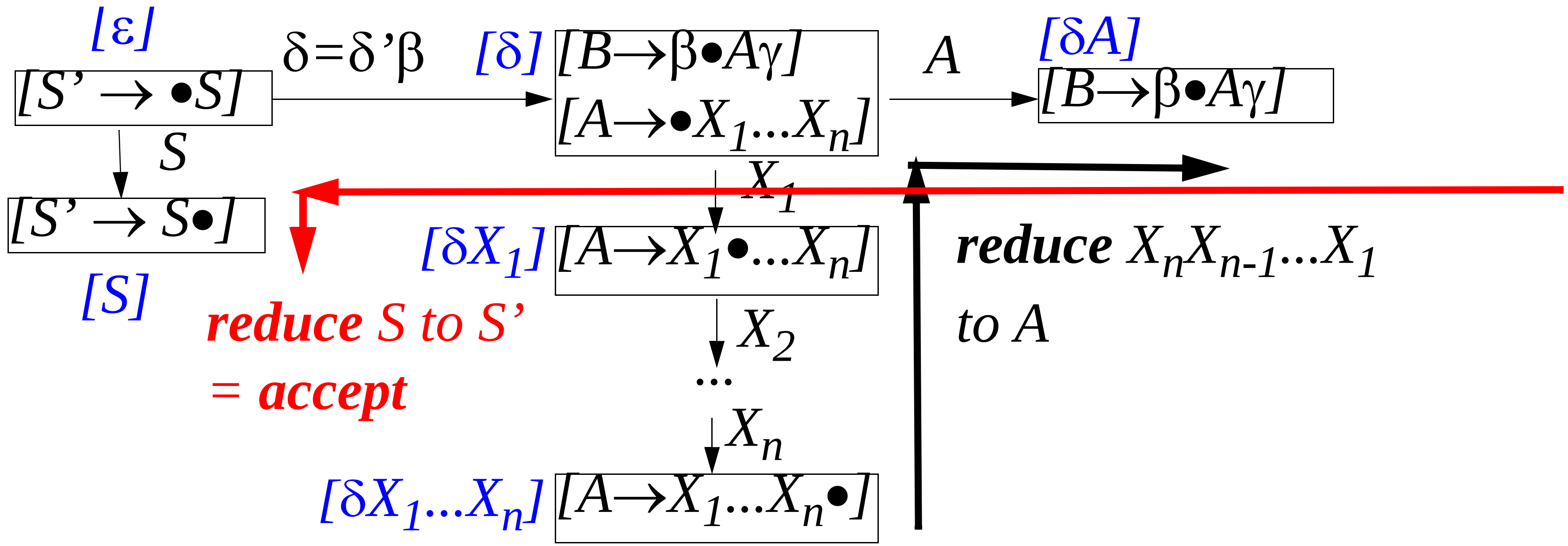
1) ***shift*** *a:* $a \in T$ $[A \to \alpha \bullet a\beta] \in [\alpha^R\delta^R]$.

$(a, [\delta^R\alpha^R]) \to (a, [a\alpha^R\delta^R][\alpha^R\delta^R])$

2) ***reduce*** α *to A:* $A \to \alpha \in P$ $[A \to \alpha\bullet] \in [\alpha^R\delta^R]$ *where* $\alpha = X_1X_2 \ldots X_n$.

$(\varepsilon, [X_nX_{n-1}\ldots X_1\delta^R][X_{n-1}\ldots X_1\delta^R] \ldots [X_2X_1\delta^R][X_1\delta^R][\delta^R])$

$\to (\varepsilon, [\delta^R A[\delta^R]])$



initial ***configuration*** $\iota = (x, [\varepsilon])$
final ***configuration*** $\Phi = \{(\varepsilon, [\varepsilon][S])\}$
LR(0) ***parser*** *for* $G = (N, T, P, S)$,

$$P_{LR(0)} = (T^* \times C_0^*, \rightarrow_{LR(0)}, (x, [\varepsilon]), (\varepsilon, [\varepsilon][S]))$$

is ***deterministic****, the G is LR(0) grammar.*

Strong *LR(k) (SLL(k))* ***parser***

SLR(k) parser $P_{SLR(k)} = (T^* \times C_0^*, \rightarrow_{SLR(k)}, (x, [\varepsilon]), (\varepsilon, [\varepsilon][S]))$ *is*

1) ***shift*** *a:* $a \in T \quad [A \rightarrow \alpha \bullet a\beta] \in [\alpha^R\delta^R]$.

$$(a, [\delta^R\alpha^R]) \rightarrow (a, [a\alpha^R\delta^R][\alpha^R\delta^R])$$

2) ***reduce*** α *to A:* $A \rightarrow \alpha \in P \; [A \rightarrow \alpha\bullet] \in [\alpha^R\delta^R]$ *where* $\alpha = X_1X_2 \ldots X_n$.

$$(x, [X_nX_{n-1}\ldots X_1\delta^R][X_{n-1}\ldots X_1\delta^R] \ldots [X_2X_1\delta^R][X_1\delta^R][\delta^R])$$

$$\rightarrow (x, [\delta^R A[\delta^R]]) \qquad x \in Follow_k(A)$$

Def. LR(k) item: $[A \to \alpha\bullet\beta, x]$, if $A \to \alpha\beta \in P$ and $x \in T^{\leq k}$.

x is called the lookahead of the LR(k) item $[A \to \alpha\bullet\beta, x]$.

Alg. Collection of ***set of*** LR(k) ***items***(LR(k) ***states***): $C_k \subseteq 2^{I_G}$.

$C_k := \{\varepsilon_k^*([S' \to \bullet S, \varepsilon])\}$ /* $[\varepsilon]$ */

where $\varepsilon_k([A \to \alpha'\bullet B\gamma', x]) = [B \to \bullet\beta, y]$, $y \in First_k(\gamma' x)$

repaeat

for $q \in C_k$ ***do***

for $[\{[A \to \alpha\bullet X\gamma, x]\} \in q$ ***do*** where $X \in N \cup T$ /* $q = [\alpha^R\delta^R]$ */

$p := \varepsilon_k^*(\{[A \to \alpha X\bullet\gamma, x]\}$; /* $p = [X\alpha^R\delta^R]$ */

if $X \in T \to$ ***shift***$(q, X) = p \mid X \in N \to$ ***goto***$(q, X) = p$ ***fi***

$C_k := C_k \cup \{q\}$

od od

until C_k does not increase

LR(k) ***parser*** *for G = (N, T, P, S) is*

$P_{LR(k)} = (T^* \times C_k^{\ *}, \rightarrow_{LR(k)}, (x, [\varepsilon]_k), (\varepsilon, [\varepsilon]_k[S]_k))$ *where*

1) ***shift*** *a:* $a \in T$ $[A \rightarrow \alpha \bullet a\beta, ax] \in [\alpha^R\delta^R], ax \in T^{\leq k}$.

$(a, [\delta^R\alpha^R]) \rightarrow (a, [a\alpha^R\delta^R][\alpha^R\delta^R])$

2) ***reduce*** *α to A:* $A \rightarrow \alpha \in P$ $[A \rightarrow \alpha\bullet, x] \in [\alpha^R\delta^R]$ *where* $\alpha = X_1X_2 \ldots X_n$.

$(x, [X_nX_{n-1}\ldots X_1\delta^R][X_{n-1}\ldots X_1\delta^R] \ldots [X_2X_1\delta^R][X_1\delta^R][\delta^R])$

$\rightarrow (x, [\delta^R A[\delta^R]])$

If LR(k) parser for G, $P_{LR(k)}$*, is deterministic G is called LR(k)* ***grammar****.*

Lookahead LR(k) ***parser*** *(LALR(k) = LR(0, k)* ***parser****)*

state: LR(0) states

reduce: LR(k) lookahead