

## NSD with right recursion

```
options
  start_node_filter = "x, u";
end

grammar NSD_right_rec
  terminal      stmt(4), cond(4), while(6);
  nonterminal   S(0), NSD(4), Stmt(4);
  start        S;

  S()          ::= NSD(x,y,u,v)                [ init ]
  NSD(x,y,u,v) ::= Stmt(x,y,r,s) NSD(r,s,u,v)  [ seq1 ]
                | Stmt(x,y,u,v)              [ seq2 ]
  Stmt(x,y,u,v) ::= stmt(x,y,u,v)            [ stmt ]
                | cond(x,y,r,s) NSD(r,m,u,n) NSD(m,s,n,v) [ cond ]
                | while(x,y,r,s,u,t) NSD(r,s,t,v) [ while ]
end
```

## NSD with left recursion

```
options
  start_node_filter = "x, u";
end

grammar NSD_left_rec
  terminal      stmt(4), cond(4), while(6);
  nonterminal   S(0), NSD(4), Stmt(4);
  start        S;

  S()          ::= NSD(x,y,u,v)                [ init ]
  NSD(x,y,u,v) ::= NSD(x,y,r,s) Stmt(r,s,u,v)  [ seq1 ]
                | Stmt(x,y,u,v)              [ seq2 ]
  Stmt(x,y,u,v) ::= stmt(x,y,u,v)            [ stmt ]
                | cond(x,y,r,s) NSD(r,m,u,n) NSD(m,s,n,v) [ cond ]
                | while(x,y,r,s,u,t) NSD(r,s,t,v) [ while ]
end
```

## NSD with right recursion

State  $q_0(a, b)$

$S()$	$\rightarrow \cdot \text{NSD}(a, n_1, \mathbf{b}, n_2)$
$\text{NSD}(a, n_3, \mathbf{b}, n_4)$	$\rightarrow \cdot \text{Stmt}(a, n_3, \mathbf{b}, n_4)$
$\text{NSD}(a, n_5, \mathbf{b}, n_6)$	$\rightarrow \cdot \text{Stmt}(a, n_5, n_7, n_8) \text{NSD}(n_7, n_8, \mathbf{b}, n_6)$
$\text{Stmt}(a, n_9, \mathbf{b}, n_{10})$	$\rightarrow \cdot \text{cond}(a, n_9, n_{11}, n_{12}) \text{NSD}(n_{11}, n_{13}, \mathbf{b}, n_{14}) \text{NSD}(n_{13}, n_{12}, n_{14}, n_{10})$
$\text{Stmt}(a, n_{15}, \mathbf{b}, n_{16})$	$\rightarrow \cdot \text{stmt}(a, n_{15}, \mathbf{b}, n_{16})$
$\text{Stmt}(a, n_{17}, \mathbf{b}, n_{18})$	$\rightarrow \cdot \text{while}(a, n_{17}, n_{19}, n_{20}, \mathbf{b}, n_{21}) \text{NSD}(n_{19}, n_{20}, n_{21}, n_{18})$
$\text{Stmt}(a, n_{22}, n_{23}, n_{24})$	$\rightarrow \cdot \text{cond}(a, n_{22}, n_{25}, n_{26}) \text{NSD}(n_{25}, n_{27}, n_{23}, n_{28}) \text{NSD}(n_{27}, n_{26}, n_{28}, n_{24})$
$\text{Stmt}(a, n_{29}, n_{30}, n_{31})$	$\rightarrow \cdot \text{stmt}(a, n_{29}, n_{30}, n_{31})$
$\text{Stmt}(a, n_{32}, n_{33}, n_{34})$	$\rightarrow \cdot \text{while}(a, n_{32}, n_{35}, n_{36}, n_{33}, n_{37}) \text{NSD}(n_{35}, n_{36}, n_{37}, n_{34})$

$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 = \mathbf{b}, n_3 \uparrow}$	$\rightarrow q_8(n_0, n_1, n_2, n_3)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 = \mathbf{b}, n_3 \uparrow}$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_5(n_0, n_1, \mathbf{b}, n_2, n_3)$
$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_3(n_0, n_1, \mathbf{b}, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 = \mathbf{b}, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{b}, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = \mathbf{a}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

State  $q_1(a, b, c, d)$

$\text{Stmt}(a, \mathbf{b}, c, d) \rightarrow \text{stmt}(a, \mathbf{b}, c, d) \cdot$	$[ \text{stmt} ]$
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State  $q_2(a, b, c, d, e, f)$

$\text{Stmt}(a, \mathbf{b}, c, n_1)$	$\rightarrow \text{while}(a, \mathbf{b}, d, e, c, \mathbf{f}) \cdot \text{NSD}(d, e, \mathbf{f}, n_1)$
$\text{NSD}(d, e, \mathbf{f}, n_2)$	$\rightarrow \cdot \text{Stmt}(d, e, \mathbf{f}, n_2)$
$\text{NSD}(d, e, \mathbf{f}, n_3)$	$\rightarrow \cdot \text{Stmt}(d, e, n_4, n_5) \text{NSD}(n_4, n_5, \mathbf{f}, n_3)$
$\text{Stmt}(d, e, \mathbf{f}, n_6)$	$\rightarrow \cdot \text{cond}(d, e, n_7, n_8) \text{NSD}(n_7, n_9, \mathbf{f}, n_{10}) \text{NSD}(n_9, n_8, n_{10}, n_6)$
$\text{Stmt}(d, e, \mathbf{f}, n_{11})$	$\rightarrow \cdot \text{stmt}(d, e, \mathbf{f}, n_{11})$
$\text{Stmt}(d, e, \mathbf{f}, n_{12})$	$\rightarrow \cdot \text{while}(d, e, n_{13}, n_{14}, \mathbf{f}, n_{15}) \text{NSD}(n_{13}, n_{14}, n_{15}, n_{12})$
$\text{Stmt}(d, e, n_{16}, n_{17})$	$\rightarrow \cdot \text{cond}(d, e, n_{18}, n_{19}) \text{NSD}(n_{18}, n_{20}, n_{16}, n_{21}) \text{NSD}(n_{20}, n_{19}, n_{21}, n_{17})$
$\text{Stmt}(d, e, n_{22}, n_{23})$	$\rightarrow \cdot \text{stmt}(d, e, n_{22}, n_{23})$
$\text{Stmt}(d, e, n_{24}, n_{25})$	$\rightarrow \cdot \text{while}(d, e, n_{26}, n_{27}, n_{24}, n_{28}) \text{NSD}(n_{26}, n_{27}, n_{28}, n_{25})$

$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 = \mathbf{f}, n_3 \uparrow}$	$\rightarrow q_9(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_3, n_0, n_1, n_2)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 = \mathbf{f}, n_3 \uparrow}$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_5(n_0, n_1, \mathbf{f}, n_2, n_3)$
$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_3(n_0, n_1, \mathbf{f}, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 = \mathbf{f}, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{f}, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

**State  $q_3(a, b, c, d, e)$**

$\text{Stmt}(a, b, c, n_1)$	$\rightarrow \text{cond}(a, b, d, e) \cdot \text{NSD}(d, n_2, c, n_3) \text{NSD}(n_2, e, n_3, n_1)$
$\text{Stmt}(a, b, n_4, n_5)$	$\rightarrow \text{cond}(a, b, d, e) \cdot \text{NSD}(d, n_6, n_4, n_7) \text{NSD}(n_6, e, n_7, n_5)$
$\text{NSD}(d, n_8, n_9, n_{10})$	$\rightarrow \cdot \text{Stmt}(d, n_8, n_{11}, n_{12}) \text{NSD}(n_{11}, n_{12}, n_9, n_{10})$
$\text{NSD}(d, n_{13}, n_{14}, n_{15})$	$\rightarrow \cdot \text{Stmt}(d, n_{13}, n_{14}, n_{15})$
$\text{NSD}(d, n_{16}, c, n_{17})$	$\rightarrow \cdot \text{Stmt}(d, n_{16}, n_{18}, n_{19}) \text{NSD}(n_{18}, n_{19}, c, n_{17})$
$\text{NSD}(d, n_{20}, c, n_{21})$	$\rightarrow \cdot \text{Stmt}(d, n_{20}, c, n_{21})$
$\text{Stmt}(d, n_{22}, n_{23}, n_{24})$	$\rightarrow \cdot \text{cond}(d, n_{22}, n_{25}, n_{26}) \text{NSD}(n_{25}, n_{27}, n_{23}, n_{28}) \text{NSD}(n_{27}, n_{26}, n_{28}, n_{24})$
$\text{Stmt}(d, n_{29}, n_{30}, n_{31})$	$\rightarrow \cdot \text{stmt}(d, n_{29}, n_{30}, n_{31})$
$\text{Stmt}(d, n_{32}, n_{33}, n_{34})$	$\rightarrow \cdot \text{while}(d, n_{32}, n_{35}, n_{36}, n_{33}, n_{37}) \text{NSD}(n_{35}, n_{36}, n_{37}, n_{34})$
$\text{Stmt}(d, n_{38}, c, n_{39})$	$\rightarrow \cdot \text{cond}(d, n_{38}, n_{40}, n_{41}) \text{NSD}(n_{40}, n_{42}, c, n_{43}) \text{NSD}(n_{42}, n_{41}, n_{43}, n_{39})$
$\text{Stmt}(d, n_{44}, c, n_{45})$	$\rightarrow \cdot \text{stmt}(d, n_{44}, c, n_{45})$
$\text{Stmt}(d, n_{46}, c, n_{47})$	$\rightarrow \cdot \text{while}(d, n_{46}, n_{48}, n_{49}, c, n_{50}) \text{NSD}(n_{48}, n_{49}, n_{50}, n_{47})$

$$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 = c, n_3 \uparrow} \rightarrow q_{10}(a, b, n_2, n_0, e, n_1, n_3)$$

$$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow} \rightarrow q_{10}(a, b, n_2, n_0, e, n_1, n_3)$$

$$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 = c, n_3 \uparrow} \rightarrow q_4(n_0, n_1, n_2, n_3)$$

$$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow} \rightarrow q_6(n_0, n_1, c, n_2, n_3)$$

$$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow} \rightarrow q_3(n_0, n_1, c, n_2, n_3)$$

$$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 = c, n_3 \uparrow} \rightarrow q_1(n_0, n_1, n_2, n_3)$$

$$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow} \rightarrow q_1(n_0, n_1, n_2, n_3)$$

$$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = d, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 = c, n_5 \uparrow} \rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$$

$$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = d, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow} \rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$$

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

$$\text{NSD}(a, b, c, d) \rightarrow \text{Stmt}(a, b, c, d) \cdot \quad [\text{seq}^2]$$

**State  $q_5(a, b, c, d, e)$**

$\text{NSD}(a, b, c, n_1)$	$\rightarrow \text{Stmt}(a, b, d, e) \cdot \text{NSD}(d, e, c, n_1)$
$\text{NSD}(d, e, c, n_2)$	$\rightarrow \cdot \text{Stmt}(d, e, n_3, n_4) \text{NSD}(n_3, n_4, c, n_2)$
$\text{NSD}(d, e, c, n_5)$	$\rightarrow \cdot \text{Stmt}(d, e, c, n_5)$
$\text{Stmt}(d, e, n_6, n_7)$	$\rightarrow \cdot \text{cond}(d, e, n_8, n_9) \text{NSD}(n_8, n_{10}, n_6, n_{11}) \text{NSD}(n_{10}, n_9, n_{11}, n_7)$
$\text{Stmt}(d, e, n_{12}, n_{13})$	$\rightarrow \cdot \text{stmt}(d, e, n_{12}, n_{13})$
$\text{Stmt}(d, e, n_{14}, n_{15})$	$\rightarrow \cdot \text{while}(d, e, n_{16}, n_{17}, n_{14}, n_{18}) \text{NSD}(n_{16}, n_{17}, n_{18}, n_{15})$
$\text{Stmt}(d, e, c, n_{19})$	$\rightarrow \cdot \text{cond}(d, e, n_{20}, n_{21}) \text{NSD}(n_{20}, n_{22}, c, n_{23}) \text{NSD}(n_{22}, n_{21}, n_{23}, n_{19})$
$\text{Stmt}(d, e, c, n_{24})$	$\rightarrow \cdot \text{stmt}(d, e, c, n_{24})$
$\text{Stmt}(d, e, c, n_{25})$	$\rightarrow \cdot \text{while}(d, e, n_{26}, n_{27}, c, n_{28}) \text{NSD}(n_{26}, n_{27}, n_{28}, n_{25})$

$$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 = e, n_2 = c, n_3 \uparrow} \rightarrow q_7(a, b, n_2, n_3, n_0, n_1)$$

$$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 = e, n_2 = c, n_3 \uparrow} \rightarrow q_4(n_0, n_1, n_2, n_3)$$

$$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow} \rightarrow q_5(n_0, n_1, c, n_2, n_3)$$

$$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow} \rightarrow q_3(n_0, n_1, c, n_2, n_3)$$

$$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 = e, n_2 = c, n_3 \uparrow} \rightarrow q_1(n_0, n_1, n_2, n_3)$$

$$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow} \rightarrow q_1(n_0, n_1, n_2, n_3)$$

$$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow, n_4 = c, n_5 \uparrow} \rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$$

$$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow} \rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$$

**State  $q_6(a, b, c, d, e)$**

NSD( $a, b, c, n_1$ )	$\rightarrow$ Stmt( $a, b, d, e$ ) . NSD( $d, e, c, n_1$ )	[seq2]
NSD( $a, b, d, e$ )	$\rightarrow$ Stmt( $a, b, d, e$ ) .	
NSD( $a, b, n_2, n_3$ )	$\rightarrow$ Stmt( $a, b, d, e$ ) . NSD( $d, e, n_2, n_3$ )	
NSD( $d, e, n_4, n_5$ )	$\rightarrow$ . Stmt( $d, e, n_6, n_7$ ) NSD( $n_6, n_7, n_4, n_5$ )	
NSD( $d, e, n_8, n_9$ )	$\rightarrow$ . Stmt( $d, e, n_8, n_9$ )	
NSD( $d, e, c, n_{10}$ )	$\rightarrow$ . Stmt( $d, e, n_{11}, n_{12}$ ) NSD( $n_{11}, n_{12}, c, n_{10}$ )	
NSD( $d, e, c, n_{13}$ )	$\rightarrow$ . Stmt( $d, e, c, n_{13}$ )	
Stmt( $d, e, n_{14}, n_{15}$ )	$\rightarrow$ . cond( $d, e, n_{16}, n_{17}$ ) NSD( $n_{16}, n_{18}, n_{14}, n_{19}$ ) NSD( $n_{18}, n_{17}, n_{19}, n_{15}$ )	
Stmt( $d, e, n_{20}, n_{21}$ )	$\rightarrow$ . stmt( $d, e, n_{20}, n_{21}$ )	
Stmt( $d, e, n_{22}, n_{23}$ )	$\rightarrow$ . while( $d, e, n_{24}, n_{25}, n_{22}, n_{26}$ ) NSD( $n_{24}, n_{25}, n_{26}, n_{23}$ )	
Stmt( $d, e, c, n_{27}$ )	$\rightarrow$ . cond( $d, e, n_{28}, n_{29}$ ) NSD( $n_{28}, n_{30}, c, n_{31}$ ) NSD( $n_{30}, n_{29}, n_{31}, n_{27}$ )	
Stmt( $d, e, c, n_{32}$ )	$\rightarrow$ . stmt( $d, e, c, n_{32}$ )	
Stmt( $d, e, c, n_{33}$ )	$\rightarrow$ . while( $d, e, n_{34}, n_{35}, c, n_{36}$ ) NSD( $n_{34}, n_{35}, n_{36}, n_{33}$ )	

NSD( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_7(a, b, n_2, n_3, n_0, n_1)$
$n_0 = d, n_1 = e, n_2 = c, n_3 \uparrow$	
NSD( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_7(a, b, n_2, n_3, n_0, n_1)$
$n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow$	
Stmt( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_4(n_0, n_1, n_2, n_3)$
$n_0 = d, n_1 = e, n_2 = c, n_3 \uparrow$	
Stmt( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_6(n_0, n_1, c, n_2, n_3)$
$n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow$	
cond( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_3(n_0, n_1, c, n_2, n_3)$
$n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow$	
stmt( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_1(n_0, n_1, n_2, n_3)$
$n_0 = d, n_1 = e, n_2 = c, n_3 \uparrow$	
stmt( $n_0, n_1, n_2, n_3$ )	$\rightarrow$ $q_1(n_0, n_1, n_2, n_3)$
$n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow$	
while( $n_0, n_1, n_2, n_3, n_4, n_5$ )	$\rightarrow$ $q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow, n_4 = c, n_5 \uparrow$	
while( $n_0, n_1, n_2, n_3, n_4, n_5$ )	$\rightarrow$ $q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$n_0 = d, n_1 = e, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow$	

**State  $q_7(a, b, c, d, e, f)$**

NSD( $a, b, c, d$ )	$\rightarrow$ Stmt( $a, b, e, f$ ) NSD( $e, f, c, d$ ) . [seq1]
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**State  $q_8(a, b, c, d)$**

S()	$\rightarrow$ NSD( $a, b, c, d$ ) . [init]
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**State  $q_9(a, b, c, d, e, f, g)$**

Stmt( $a, b, c, d$ )	$\rightarrow$ while( $a, b, e, f, c, g$ ) NSD( $e, f, g, d$ ) . [while]
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**State  $q_{10}(a, b, c, d, e, f, g)$**

Stmt( $a, b, c, n_1$ )	$\rightarrow$ cond( $a, b, d, e$ ) NSD( $d, f, c, g$ ) . NSD( $f, e, g, n_1$ )
NSD( $f, e, g, n_2$ )	$\rightarrow$ . Stmt( $f, e, g, n_2$ )
NSD( $f, e, g, n_3$ )	$\rightarrow$ . Stmt( $f, e, n_4, n_5$ ) NSD( $n_4, n_5, g, n_3$ )
Stmt( $f, e, g, n_6$ )	$\rightarrow$ . cond( $f, e, n_7, n_8$ ) NSD( $n_7, n_9, g, n_{10}$ ) NSD( $n_9, n_8, n_{10}, n_6$ )
Stmt( $f, e, g, n_{11}$ )	$\rightarrow$ . stmt( $f, e, g, n_{11}$ )
Stmt( $f, e, g, n_{12}$ )	$\rightarrow$ . while( $f, e, n_{13}, n_{14}, g, n_{15}$ ) NSD( $n_{13}, n_{14}, n_{15}, n_{12}$ )
Stmt( $f, e, n_{16}, n_{17}$ )	$\rightarrow$ . cond( $f, e, n_{18}, n_{19}$ ) NSD( $n_{18}, n_{20}, n_{16}, n_{21}$ ) NSD( $n_{20}, n_{19}, n_{21}, n_{17}$ )
Stmt( $f, e, n_{22}, n_{23}$ )	$\rightarrow$ . stmt( $f, e, n_{22}, n_{23}$ )
Stmt( $f, e, n_{24}, n_{25}$ )	$\rightarrow$ . while( $f, e, n_{26}, n_{27}, n_{24}, n_{28}$ ) NSD( $n_{26}, n_{27}, n_{28}, n_{25}$ )

$$\begin{array}{l}
\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 = \mathbf{g}, n_3 \uparrow} \rightarrow q_{11}(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_3, \mathbf{d}, n_1, n_0, n_2) \\
\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 = \mathbf{g}, n_3 \uparrow} \rightarrow q_4(n_0, n_1, n_2, n_3) \\
\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow} \rightarrow q_5(n_0, n_1, \mathbf{g}, n_2, n_3) \\
\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow} \rightarrow q_3(n_0, n_1, \mathbf{g}, n_2, n_3) \\
\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 = \mathbf{g}, n_3 \uparrow} \rightarrow q_1(n_0, n_1, n_2, n_3) \\
\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow} \rightarrow q_1(n_0, n_1, n_2, n_3) \\
\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{g}, n_5 \uparrow} \rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5) \\
\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow} \rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)
\end{array}$$

**State**  $q_{11}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}, \mathbf{e}, \mathbf{f}, \mathbf{g}, \mathbf{h})$

$\text{Stmt}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \rightarrow \text{cond}(\mathbf{a}, \mathbf{b}, \mathbf{e}, \mathbf{f}) \text{NSD}(\mathbf{e}, \mathbf{g}, \mathbf{c}, \mathbf{h}) \text{NSD}(\mathbf{g}, \mathbf{f}, \mathbf{h}, \mathbf{d}) \cdot \quad [\text{cond}]$
---

## NSD with left recursion

### State $q_0(a, b)$

$S()$	$\rightarrow \cdot \text{NSD}(a, n_1, b, n_2)$
$\text{NSD}(a, n_3, b, n_4)$	$\rightarrow \cdot \text{NSD}(a, n_3, n_5, n_6) \text{ Stmt}(n_5, n_6, b, n_4)$
$\text{NSD}(a, n_7, b, n_8)$	$\rightarrow \cdot \text{Stmt}(a, n_7, b, n_8)$
$\text{NSD}(a, n_9, n_{10}, n_{11})$	$\rightarrow \cdot \text{NSD}(a, n_9, n_{12}, n_{13}) \text{ Stmt}(n_{12}, n_{13}, n_{10}, n_{11})$
$\text{NSD}(a, n_{14}, n_{15}, n_{16})$	$\rightarrow \cdot \text{Stmt}(a, n_{14}, n_{15}, n_{16})$
$\text{Stmt}(a, n_{17}, b, n_{18})$	$\rightarrow \cdot \text{cond}(a, n_{17}, n_{19}, n_{20}) \text{NSD}(n_{19}, n_{21}, b, n_{22}) \text{NSD}(n_{21}, n_{20}, n_{22}, n_{18})$
$\text{Stmt}(a, n_{23}, b, n_{24})$	$\rightarrow \cdot \text{stmt}(a, n_{23}, b, n_{24})$
$\text{Stmt}(a, n_{25}, b, n_{26})$	$\rightarrow \cdot \text{while}(a, n_{25}, n_{27}, n_{28}, b, n_{29}) \text{NSD}(n_{27}, n_{28}, n_{29}, n_{26})$
$\text{Stmt}(a, n_{30}, n_{31}, n_{32})$	$\rightarrow \cdot \text{cond}(a, n_{30}, n_{33}, n_{34}) \text{NSD}(n_{33}, n_{35}, n_{31}, n_{36}) \text{NSD}(n_{35}, n_{34}, n_{36}, n_{32})$
$\text{Stmt}(a, n_{37}, n_{38}, n_{39})$	$\rightarrow \cdot \text{stmt}(a, n_{37}, n_{38}, n_{39})$
$\text{Stmt}(a, n_{40}, n_{41}, n_{42})$	$\rightarrow \cdot \text{while}(a, n_{40}, n_{43}, n_{44}, n_{41}, n_{45}) \text{NSD}(n_{43}, n_{44}, n_{45}, n_{42})$

$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 = b, n_3 \uparrow}$	$\rightarrow q_6(n_0, n_1, n_2, n_3)$
$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_5(n_0, n_1, n_2, n_3, b)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 = b, n_3 \uparrow}$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_3(n_0, n_1, b, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 = b, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = a, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = a, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 = b, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = a, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

### State $q_1(a, b, c, d)$

$\text{Stmt}(a, b, c, d) \rightarrow \text{stmt}(a, b, c, d) \cdot$	$[ \text{stmt} ]$
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### State $q_2(a, b, c, d, e, f)$

$\text{Stmt}(a, b, c, n_1)$	$\rightarrow \text{while}(a, b, d, e, c, f) \cdot \text{NSD}(d, e, f, n_1)$
$\text{NSD}(d, e, f, n_2)$	$\rightarrow \cdot \text{NSD}(d, e, n_3, n_4) \text{ Stmt}(n_3, n_4, f, n_2)$
$\text{NSD}(d, e, f, n_5)$	$\rightarrow \cdot \text{Stmt}(d, e, f, n_5)$
$\text{NSD}(d, e, n_6, n_7)$	$\rightarrow \cdot \text{NSD}(d, e, n_8, n_9) \text{ Stmt}(n_8, n_9, n_6, n_7)$
$\text{NSD}(d, e, n_{10}, n_{11})$	$\rightarrow \cdot \text{Stmt}(d, e, n_{10}, n_{11})$
$\text{Stmt}(d, e, f, n_{12})$	$\rightarrow \cdot \text{cond}(d, e, n_{13}, n_{14}) \text{NSD}(n_{13}, n_{15}, f, n_{16}) \text{NSD}(n_{15}, n_{14}, n_{16}, n_{12})$
$\text{Stmt}(d, e, f, n_{17})$	$\rightarrow \cdot \text{stmt}(d, e, f, n_{17})$
$\text{Stmt}(d, e, f, n_{18})$	$\rightarrow \cdot \text{while}(d, e, n_{19}, n_{20}, f, n_{21}) \text{NSD}(n_{19}, n_{20}, n_{21}, n_{18})$
$\text{Stmt}(d, e, n_{22}, n_{23})$	$\rightarrow \cdot \text{cond}(d, e, n_{24}, n_{25}) \text{NSD}(n_{24}, n_{26}, n_{22}, n_{27}) \text{NSD}(n_{26}, n_{25}, n_{27}, n_{23})$
$\text{Stmt}(d, e, n_{28}, n_{29})$	$\rightarrow \cdot \text{stmt}(d, e, n_{28}, n_{29})$
$\text{Stmt}(d, e, n_{30}, n_{31})$	$\rightarrow \cdot \text{while}(d, e, n_{32}, n_{33}, n_{30}, n_{34}) \text{NSD}(n_{32}, n_{33}, n_{34}, n_{31})$

$\text{NSD}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 = \mathbf{f}, n_3 \uparrow$	$\rightarrow q_7(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_3, n_0, n_1, n_2)$
$\text{NSD}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_5(n_0, n_1, n_2, n_3, \mathbf{f})$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 = \mathbf{f}, n_3 \uparrow$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\text{cond}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_3(n_0, n_1, \mathbf{f}, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 = \mathbf{f}, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{f}, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{d}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

### State $q_3(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}, \mathbf{e})$

$\text{Stmt}(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_1)$	$\rightarrow \text{cond}(\mathbf{a}, \mathbf{b}, \mathbf{d}, \mathbf{e}) \cdot \text{NSD}(\mathbf{d}, n_2, \mathbf{c}, n_3) \text{NSD}(n_2, \mathbf{e}, n_3, n_1)$
$\text{Stmt}(\mathbf{a}, \mathbf{b}, n_4, n_5)$	$\rightarrow \text{cond}(\mathbf{a}, \mathbf{b}, \mathbf{d}, \mathbf{e}) \cdot \text{NSD}(\mathbf{d}, n_6, n_4, n_7) \text{NSD}(n_6, \mathbf{e}, n_7, n_5)$
$\text{NSD}(\mathbf{d}, n_8, n_9, n_{10})$	$\rightarrow \cdot \text{NSD}(\mathbf{d}, n_8, n_{11}, n_{12}) \text{Stmt}(n_{11}, n_{12}, n_9, n_{10})$
$\text{NSD}(\mathbf{d}, n_{13}, n_{14}, n_{15})$	$\rightarrow \cdot \text{Stmt}(\mathbf{d}, n_{13}, n_{14}, n_{15})$
$\text{NSD}(\mathbf{d}, n_{16}, \mathbf{c}, n_{17})$	$\rightarrow \cdot \text{NSD}(\mathbf{d}, n_{16}, n_{18}, n_{19}) \text{Stmt}(n_{18}, n_{19}, \mathbf{c}, n_{17})$
$\text{NSD}(\mathbf{d}, n_{20}, \mathbf{c}, n_{21})$	$\rightarrow \cdot \text{Stmt}(\mathbf{d}, n_{20}, \mathbf{c}, n_{21})$
$\text{Stmt}(\mathbf{d}, n_{22}, n_{23}, n_{24})$	$\rightarrow \cdot \text{cond}(\mathbf{d}, n_{22}, n_{25}, n_{26}) \text{NSD}(n_{25}, n_{27}, n_{23}, n_{28}) \text{NSD}(n_{27}, n_{26}, n_{28}, n_{24})$
$\text{Stmt}(\mathbf{d}, n_{29}, n_{30}, n_{31})$	$\rightarrow \cdot \text{stmt}(\mathbf{d}, n_{29}, n_{30}, n_{31})$
$\text{Stmt}(\mathbf{d}, n_{32}, n_{33}, n_{34})$	$\rightarrow \cdot \text{while}(\mathbf{d}, n_{32}, n_{35}, n_{36}, n_{33}, n_{37}) \text{NSD}(n_{35}, n_{36}, n_{37}, n_{34})$
$\text{Stmt}(\mathbf{d}, n_{38}, \mathbf{c}, n_{39})$	$\rightarrow \cdot \text{cond}(\mathbf{d}, n_{38}, n_{40}, n_{41}) \text{NSD}(n_{40}, n_{42}, \mathbf{c}, n_{43}) \text{NSD}(n_{42}, n_{41}, n_{43}, n_{39})$
$\text{Stmt}(\mathbf{d}, n_{44}, \mathbf{c}, n_{45})$	$\rightarrow \cdot \text{stmt}(\mathbf{d}, n_{44}, \mathbf{c}, n_{45})$
$\text{Stmt}(\mathbf{d}, n_{46}, \mathbf{c}, n_{47})$	$\rightarrow \cdot \text{while}(\mathbf{d}, n_{46}, n_{48}, n_{49}, \mathbf{c}, n_{50}) \text{NSD}(n_{48}, n_{49}, n_{50}, n_{47})$

$\text{NSD}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 = \mathbf{c}, n_3 \uparrow$	$\rightarrow q_8(\mathbf{a}, \mathbf{b}, n_2, n_0, \mathbf{e}, n_1, n_3)$
$\text{NSD}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_9(n_0, n_1, n_2, n_3, \mathbf{c}, \mathbf{a}, \mathbf{b}, \mathbf{e})$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 = \mathbf{c}, n_3 \uparrow$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\text{cond}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_3(n_0, n_1, \mathbf{c}, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 = \mathbf{c}, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{c}, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{d}, n_1 \uparrow, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

### State $q_4(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d})$

$\text{NSD}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \rightarrow \text{Stmt}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \cdot \text{[seq2]}$
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### State $q_5(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}, \mathbf{e})$

$\text{NSD}(\mathbf{a}, \mathbf{b}, n_1, n_2)$	$\rightarrow \text{NSD}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \cdot \text{Stmt}(\mathbf{c}, \mathbf{d}, n_1, n_2)$
$\text{NSD}(\mathbf{a}, \mathbf{b}, \mathbf{e}, n_3)$	$\rightarrow \text{NSD}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \cdot \text{Stmt}(\mathbf{c}, \mathbf{d}, \mathbf{e}, n_3)$
$\text{Stmt}(\mathbf{c}, \mathbf{d}, n_4, n_5)$	$\rightarrow \cdot \text{cond}(\mathbf{c}, \mathbf{d}, n_6, n_7) \text{NSD}(n_6, n_8, n_4, n_9) \text{NSD}(n_8, n_7, n_9, n_5)$
$\text{Stmt}(\mathbf{c}, \mathbf{d}, n_{10}, n_{11})$	$\rightarrow \cdot \text{stmt}(\mathbf{c}, \mathbf{d}, n_{10}, n_{11})$
$\text{Stmt}(\mathbf{c}, \mathbf{d}, n_{12}, n_{13})$	$\rightarrow \cdot \text{while}(\mathbf{c}, \mathbf{d}, n_{14}, n_{15}, n_{12}, n_{16}) \text{NSD}(n_{14}, n_{15}, n_{16}, n_{13})$
$\text{Stmt}(\mathbf{c}, \mathbf{d}, \mathbf{e}, n_{17})$	$\rightarrow \cdot \text{cond}(\mathbf{c}, \mathbf{d}, n_{18}, n_{19}) \text{NSD}(n_{18}, n_{20}, \mathbf{e}, n_{21}) \text{NSD}(n_{20}, n_{19}, n_{21}, n_{17})$
$\text{Stmt}(\mathbf{c}, \mathbf{d}, \mathbf{e}, n_{22})$	$\rightarrow \cdot \text{stmt}(\mathbf{c}, \mathbf{d}, \mathbf{e}, n_{22})$
$\text{Stmt}(\mathbf{c}, \mathbf{d}, \mathbf{e}, n_{23})$	$\rightarrow \cdot \text{while}(\mathbf{c}, \mathbf{d}, n_{24}, n_{25}, \mathbf{e}, n_{26}) \text{NSD}(n_{24}, n_{25}, n_{26}, n_{23})$

$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 = \mathbf{e}, n_3 \uparrow$	$\rightarrow q_{10}(\mathbf{a}, \mathbf{b}, n_2, n_3, n_0, n_1)$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_{10}(\mathbf{a}, \mathbf{b}, n_2, n_3, n_0, n_1)$
$\text{cond}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_3(n_0, n_1, \mathbf{e}, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 = \mathbf{e}, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{e}, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{c}, n_1 = \mathbf{d}, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

**State  $q_6(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d})$**

$S() \rightarrow \text{NSD}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \cdot \quad [\text{init}]$

**State  $q_7(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}, \mathbf{e}, \mathbf{f}, \mathbf{g})$**

$\text{Stmt}(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}) \rightarrow \text{while}(\mathbf{a}, \mathbf{b}, \mathbf{e}, \mathbf{f}, \mathbf{c}, \mathbf{g}) \text{NSD}(\mathbf{e}, \mathbf{f}, \mathbf{g}, \mathbf{d}) \cdot \quad [\text{while}]$

**State  $q_8(\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}, \mathbf{e}, \mathbf{f}, \mathbf{g})$**

$\text{Stmt}(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_1)$	$\rightarrow \text{cond}(\mathbf{a}, \mathbf{b}, \mathbf{d}, \mathbf{e}) \text{NSD}(\mathbf{d}, \mathbf{f}, \mathbf{c}, \mathbf{g}) \cdot \text{NSD}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_1)$
$\text{NSD}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_2)$	$\rightarrow \cdot \text{NSD}(\mathbf{f}, \mathbf{e}, n_3, n_4) \text{Stmt}(n_3, n_4, \mathbf{g}, n_2)$
$\text{NSD}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_5)$	$\rightarrow \cdot \text{Stmt}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_5)$
$\text{NSD}(\mathbf{f}, \mathbf{e}, n_6, n_7)$	$\rightarrow \cdot \text{NSD}(\mathbf{f}, \mathbf{e}, n_8, n_9) \text{Stmt}(n_8, n_9, n_6, n_7)$
$\text{NSD}(\mathbf{f}, \mathbf{e}, n_{10}, n_{11})$	$\rightarrow \cdot \text{Stmt}(\mathbf{f}, \mathbf{e}, n_{10}, n_{11})$
$\text{Stmt}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_{12})$	$\rightarrow \cdot \text{cond}(\mathbf{f}, \mathbf{e}, n_{13}, n_{14}) \text{NSD}(n_{13}, n_{15}, \mathbf{g}, n_{16}) \text{NSD}(n_{15}, n_{14}, n_{16}, n_{12})$
$\text{Stmt}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_{17})$	$\rightarrow \cdot \text{stmt}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_{17})$
$\text{Stmt}(\mathbf{f}, \mathbf{e}, \mathbf{g}, n_{18})$	$\rightarrow \cdot \text{while}(\mathbf{f}, \mathbf{e}, n_{19}, n_{20}, \mathbf{g}, n_{21}) \text{NSD}(n_{19}, n_{20}, n_{21}, n_{18})$
$\text{Stmt}(\mathbf{f}, \mathbf{e}, n_{22}, n_{23})$	$\rightarrow \cdot \text{cond}(\mathbf{f}, \mathbf{e}, n_{24}, n_{25}) \text{NSD}(n_{24}, n_{26}, n_{22}, n_{27}) \text{NSD}(n_{26}, n_{25}, n_{27}, n_{23})$
$\text{Stmt}(\mathbf{f}, \mathbf{e}, n_{28}, n_{29})$	$\rightarrow \cdot \text{stmt}(\mathbf{f}, \mathbf{e}, n_{28}, n_{29})$
$\text{Stmt}(\mathbf{f}, \mathbf{e}, n_{30}, n_{31})$	$\rightarrow \cdot \text{while}(\mathbf{f}, \mathbf{e}, n_{32}, n_{33}, n_{30}, n_{34}) \text{NSD}(n_{32}, n_{33}, n_{34}, n_{31})$

$\text{NSD}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 = \mathbf{g}, n_3 \uparrow$	$\rightarrow q_{11}(\mathbf{a}, \mathbf{b}, \mathbf{c}, n_3, \mathbf{d}, n_1, n_0, n_2)$
$\text{NSD}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_5(n_0, n_1, n_2, n_3, \mathbf{g})$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 = \mathbf{g}, n_3 \uparrow$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\text{Stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\text{cond}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_3(n_0, n_1, \mathbf{g}, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 = \mathbf{g}, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{stmt}(n_0, n_1, n_2, n_3)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 = \mathbf{g}, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)$ $n_0 = \mathbf{f}, n_1 = \mathbf{e}, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

**State  $q_9(a, b, c, d, e, f, g, h)$**

$\text{NSD}(a, b, n_1, n_2)$	$\rightarrow \text{NSD}(a, b, c, d) \cdot \text{Stmt}(c, d, n_1, n_2)$
$\text{NSD}(a, b, e, n_3)$	$\rightarrow \text{NSD}(a, b, c, d) \cdot \text{Stmt}(c, d, e, n_3)$
$\text{Stmt}(f, g, c, n_4)$	$\rightarrow \text{cond}(f, g, a, h) \text{NSD}(a, b, c, d) \cdot \text{NSD}(b, h, d, n_4)$
$\text{NSD}(b, h, d, n_5)$	$\rightarrow \cdot \text{NSD}(b, h, n_6, n_7) \text{Stmt}(n_6, n_7, d, n_5)$
$\text{NSD}(b, h, d, n_8)$	$\rightarrow \cdot \text{Stmt}(b, h, d, n_8)$
$\text{NSD}(b, h, n_9, n_{10})$	$\rightarrow \cdot \text{NSD}(b, h, n_{11}, n_{12}) \text{Stmt}(n_{11}, n_{12}, n_9, n_{10})$
$\text{NSD}(b, h, n_{13}, n_{14})$	$\rightarrow \cdot \text{Stmt}(b, h, n_{13}, n_{14})$
$\text{Stmt}(b, h, d, n_{15})$	$\rightarrow \cdot \text{cond}(b, h, n_{16}, n_{17}) \text{NSD}(n_{16}, n_{18}, d, n_{19}) \text{NSD}(n_{18}, n_{17}, n_{19}, n_{15})$
$\text{Stmt}(b, h, d, n_{20})$	$\rightarrow \cdot \text{stmt}(b, h, d, n_{20})$
$\text{Stmt}(b, h, d, n_{21})$	$\rightarrow \cdot \text{while}(b, h, n_{22}, n_{23}, d, n_{24}) \text{NSD}(n_{22}, n_{23}, n_{24}, n_{21})$
$\text{Stmt}(b, h, n_{25}, n_{26})$	$\rightarrow \cdot \text{cond}(b, h, n_{27}, n_{28}) \text{NSD}(n_{27}, n_{29}, n_{25}, n_{30}) \text{NSD}(n_{29}, n_{28}, n_{30}, n_{26})$
$\text{Stmt}(b, h, n_{31}, n_{32})$	$\rightarrow \cdot \text{stmt}(b, h, n_{31}, n_{32})$
$\text{Stmt}(b, h, n_{33}, n_{34})$	$\rightarrow \cdot \text{while}(b, h, n_{35}, n_{36}, n_{33}, n_{37}) \text{NSD}(n_{35}, n_{36}, n_{37}, n_{34})$
$\text{Stmt}(c, d, n_{38}, n_{39})$	$\rightarrow \cdot \text{cond}(c, d, n_{40}, n_{41}) \text{NSD}(n_{40}, n_{42}, n_{38}, n_{43}) \text{NSD}(n_{42}, n_{41}, n_{43}, n_{39})$
$\text{Stmt}(c, d, n_{44}, n_{45})$	$\rightarrow \cdot \text{stmt}(c, d, n_{44}, n_{45})$
$\text{Stmt}(c, d, n_{46}, n_{47})$	$\rightarrow \cdot \text{while}(c, d, n_{48}, n_{49}, n_{46}, n_{50}) \text{NSD}(n_{48}, n_{49}, n_{50}, n_{47})$
$\text{Stmt}(c, d, e, n_{51})$	$\rightarrow \cdot \text{cond}(c, d, n_{52}, n_{53}) \text{NSD}(n_{52}, n_{54}, e, n_{55}) \text{NSD}(n_{54}, n_{53}, n_{55}, n_{51})$
$\text{Stmt}(c, d, e, n_{56})$	$\rightarrow \cdot \text{stmt}(c, d, e, n_{56})$
$\text{Stmt}(c, d, e, n_{57})$	$\rightarrow \cdot \text{while}(c, d, n_{58}, n_{59}, e, n_{60}) \text{NSD}(n_{58}, n_{59}, n_{60}, n_{57})$

$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 = d, n_3 \uparrow}$	$\rightarrow q_{11}(f, g, c, n_3, a, n_1, n_0, n_2)$
$\frac{\text{NSD}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_5(n_0, n_1, n_2, n_3, d)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 = d, n_3 \uparrow}$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_4(n_0, n_1, n_2, n_3)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = c, n_1 = d, n_2 = e, n_3 \uparrow}$	$\rightarrow q_{10}(a, b, n_2, n_3, n_0, n_1)$
$\frac{\text{Stmt}(n_0, n_1, n_2, n_3)}{n_0 = c, n_1 = d, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_{10}(a, b, n_2, n_3, n_0, n_1)$
$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_3(n_0, n_1, d, n_2, n_3)$
$\frac{\text{cond}(n_0, n_1, n_2, n_3)}{n_0 = c, n_1 = d, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_3(n_0, n_1, e, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 = d, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = b, n_1 = h, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = c, n_1 = d, n_2 = e, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{stmt}(n_0, n_1, n_2, n_3)}{n_0 = c, n_1 = d, n_2 \uparrow, n_3 \uparrow}$	$\rightarrow q_1(n_0, n_1, n_2, n_3)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = b, n_1 = h, n_2 \uparrow, n_3 \uparrow, n_4 = d, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = b, n_1 = h, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = c, n_1 = d, n_2 \uparrow, n_3 \uparrow, n_4 = e, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$
$\frac{\text{while}(n_0, n_1, n_2, n_3, n_4, n_5)}{n_0 = c, n_1 = d, n_2 \uparrow, n_3 \uparrow, n_4 \uparrow, n_5 \uparrow}$	$\rightarrow q_2(n_0, n_1, n_4, n_2, n_3, n_5)$

**State  $q_{10}(a, b, c, d, e, f)$**

$\text{NSD}(a, b, c, d) \rightarrow \text{NSD}(a, b, e, f) \text{Stmt}(e, f, c, d) \cdot$	$[seq1]$
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**State  $q_{11}(a, b, c, d, e, f, g, h)$**

$\text{Stmt}(a, b, c, d) \rightarrow \text{cond}(a, b, e, f) \text{NSD}(e, g, c, h) \text{NSD}(g, f, h, d) \cdot$	$[cond]$
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