1. $a^n c b^n$, n>=1   w=acb,aacbb,aaacbbb

δ(q0,a,z0)=(q0,az0)

δ(q0,a,a)=(q0,aa)

δ(q0,c,a)=(q1,a)

δ(q1,b,a)=(q1,€)

δ(q1, €,z0)=(q2,z0)------- by final state

δ(q1, €,z0)=(q1, €)----------by null stack

2. $a^n b^n c^m$ /n,m>=1   w=abc,abcc,aabbc,bc(invalid)

δ(q0,a,z0)=(q0,az0)

δ(q0,a,a)=(q0,aa)

δ(q0,b,a)=(q1,€)

δ(q1,b,a)=(q1,€)

δ(q1,c,z0)=(q2,z0)

δ(q2,c,z0)=(q2,z0)----------by final state

3. $a^n b^m c^n$ /n,m>=1

CFG to PDA

Construct a PDA ‘P’ that accepts L(G) by empty stack as follows

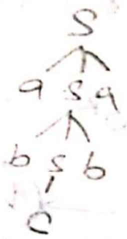
P=[{q},T,VUT, δ,q,S]

δ is defined by

1. for each variable ‘A’
   δ(q,€,A)={(q, β)|A->β is a production of P}
2. for each terminal ‘a’, δ(q,a,a)={(q, €)}

$S \to aSa \mid bSb \mid c$

$\delta(q, \epsilon, S) = \{(q, aSa), (q, bSb), (q, c)\}$



$\delta(q, a, a) = \{(q, \epsilon)\}$

$\delta(q, b, b) = \{(q, \epsilon)\}$

$\delta(q, c, c) = \{(q, \epsilon)\}$

$w = abcba$

$(q, abcba, S) \vdash (q, abcba, aSa)$

$\vdash (q, bcba, Sa)$

$\vdash (q, bcba, bSba)$

$\vdash (q, cba, Sba) \vdash (q, cba, cba)$

$\vdash (q, ba, ba) \vdash (q, a, a) \vdash (q, \epsilon)$

3. S->aAA,A->aS|bS|a

   W=abaaaa

4. S->AB
   B->b
   A->CD
   C->a
   D->a
   W=aab

2. $E \rightarrow I \mid E+E \mid E*E \mid (E)$ $\qquad W = aa*a0$

$I \rightarrow a \mid Ia \mid 0 \mid I0$

$\delta(q, \epsilon, E) = \{(q, I), (q, E+E), (q, E*E), (q, (E))\}$

$\delta(q, \epsilon, I) = \{(q, a), (q, 0), (q, Ia), (q, I0)\}$

Δ(q,+,+)=(q,€)

Δ(q,*,*)=(q,€)

Δ(q,(,()=(q,€)

Δ(q,),))=(q,€)

Δ(q,a,a)=(q,€)

Δ(q,0,0)=(q,€)

(E*E)

(I*E)

(Ia*E)

(aa*E) (a*E) (*E) (E) (I) (I0) (a0) (0) (epsilon)

PDA to CFG

Let M =(Q, Σ ,Γ ,δ ,q0 ,Z0 ,Ø) be a PDA accepting L by empty store

Construct G=(V,T,P,S) such that L(G)=N(M)

P: S-> [q0,z0,p] for each P in Q

Rules for mapping

1. If δ(q1,a,A) contains (P,B1,B2---Bm) m≠0
   P contains
   [q1,A,qm+1]-> a[P,B1,q2][q2,B2,q3][q3,B3,q4]-----[qm,Bm,qm+1]
   x€ΣU{€}
2. If δ(q,a,A) contains (P, €) m=0
   [q,A,P]->a€P

EX:1 M=({q0,q1},{0,1},{z0,x}, δ,q0,z0, Ø)

(i) δ(q0,0,z0)={(q0,XZ0)}
(ii) δ(q0,0,X)={(q0,XX)}
(iii) δ(q0,1,X)={(q1,€)}
(iv) δ(q1,1,X)={(q1,€)}
(v) δ(q1,€,X)={(q1,€)}
(vi) δ(q1,€,Z0)={(q1,€)}

What is N(M)?

SOL: step 1: S->[q0,z0,q0] / S->[q0,z0,q1]

Step 2: [q0,X,q1]->1

[q1,X,q1]->1

[q1,X,q1]->€

[q1,Z0,q1]->€

[q0,z0,q1]

Step 3: (i) δ(q0,0,z0)={(q0,XZ0)}

[q0,z0,q0]=0[q0,X,q0][q0,Z0,q0]

[q0,z0,q0]=0[q0,X,q1][q1,Z0,q0]

[q0,z0,q1]=0[q0,X,q0][q0,Z0,q1]

[q0,z0,q1]=0[q0,X,q1][q1,Z0,q1]------------→

(ii) δ(q0,0,X)={(q0,XX)}

[q0,X,q0]=0[q0,X,q0][q0,X,q0]

[q0,X,q0]=0[q0,X,q1][q1,X,q0]

[q0,X,q1]=0[q0,X,q0][q0,X,q1]

[q0,X,q1]=0[q0,X,q1][q1,X,q1]-----------→

Final Productions

A

S->[q0,z0,q1]

B

[q0,X,q1]->1

D

[q1,X,q1]->1

D

[q1,X,q1]->€

C

[q1,Z0,q1]->€

A -> 0BC

[q0,z0,q1]=0[q0,x,q1][q1,z0,q1]

B-> 0BD|1

[q0,X,q1]=0[q0,x,q1][q1,X,q1]

S-> A

A->0BC

B->0BD|1

C->€

D->1|€ 0^m1^n/m,n>=1 01,0011,00001

2. $\delta(q_0, 1, z_0) = (q_0, x z_0)$

$\delta(q_0, 1, x) = (q_0, x x)$

$\delta(q_0, 0, x) = (q_1, x)$

$\delta(q_1, 0, z_0) = (q_0, z_0)$

$\delta(q_0, \epsilon, z_0) = (q_0, \epsilon)$

$\delta(q_1, 1, x) = (q_1, \epsilon)$

$\delta(q_0, 0, x) = (q_1, x)$

$[q_0, x, q_0] \rightarrow 0\,[q_1, x, q_0]$

$[q_0, x, q_1] \rightarrow 0\,[q_1, x, q_1]$

Final Productions

$S \rightarrow [q_0, Z_0, q_0]$

$[q_0, Z_0, q_0] \rightarrow \epsilon$

$[q_1, X, q_1] \rightarrow 1$

$[q_0, Z_0, q_0] \rightarrow 1\, [q_0, X, q_1]\, [q_1, Z_0, q_0]$

$[q_0, X, q_1] \rightarrow 1\, [q_0, X, q_1]\, [q_1, X, q_1]$

$[q_0, X, q_1] \rightarrow 0\, [q_1, X, q_1]$

$[q_1, Z_0, q_0] \rightarrow 0\, [q_0, Z_0, q_0)$

(i) δ(q,1,z)={(q,XZ)}
(ii) δ(q,1,X)={(q,XX)}
(iii) δ(q, €,X)={(q,€)}
(iv) δ(q,0,Z)={(p,X)}
(v) δ(p,1,X)={(p,€)}
(vi) δ(p,0,Z)={(q,Z)}

S->[q,z,q]

S->[q,z,p]