中山大學 SUN YAT-SEN UNIVERSITY
计算机学院（软件学院）
SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

Compilation Principle
编 译 原 理

第12讲：语法分析(9)

张献伟

xianweiz.github.io

DCS290, 4/4/2023

Quiz Questions

- Q1: main differences between LL and LR parse table?

  LL: row – nonterminal, column – terminal + $, cell – rule or empty

  LR: action + goto, row – state, column – T+$/N, cell – action/state

- Q2: for a sentential form bbAa: $S \Rightarrow^*_{rm} bBa \Rightarrow bbAa$, suppose bA is the handle, list the viable prefix.

  b, bb, bbA

- Q3: for the grammar, get FIRST(*S*) and FOLLOW(*A*).

  FIRST(*S*) = {a, b}, FOLLOW(*A*) = {b}

- Q4: is the grammar a LL(1)?

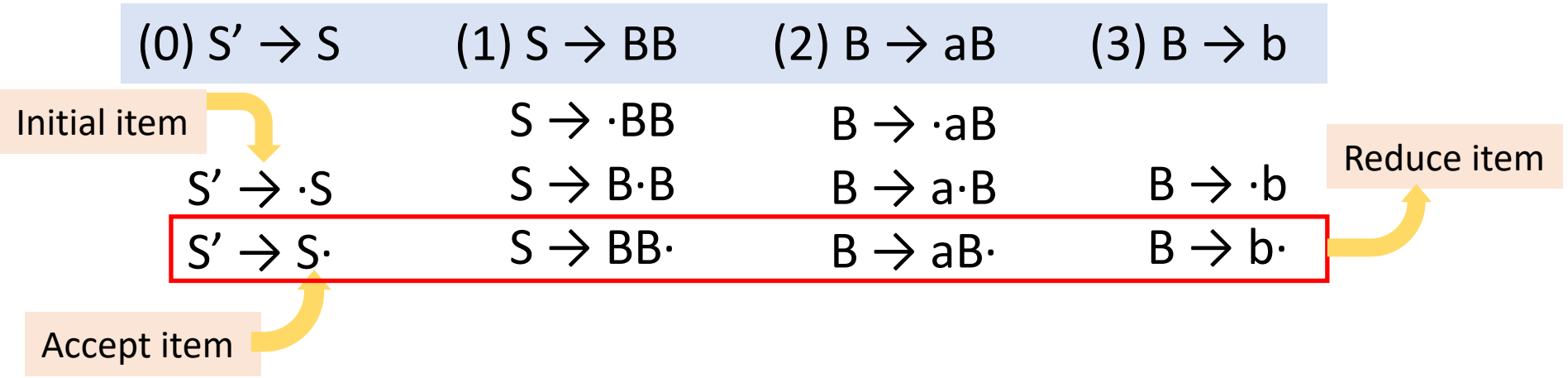
  NO. FIRST(AB) ∩ FIRST(a) ≠ ∅.

  S → AB | a
  A → a | ε
  B → b

- Q5: augment the grammar, and give the initial state (S_0).

  { S' → .S, S → .AB, S → .a, A → .a, A → . }

Example



- **Closure**: the action of adding equivalent items to a set
  - Example: S' → ·S S → ·BB B → ·aB B → ·b
- Intuitively, A → α·Bβ means that we might next see a substring derivable from Bβ (_*sub*) as input. The _*sub* will have a prefix derivable from B by applying one of the B-productions[期待意义等价]
  - Thus, we add items for all the B-productions, i.e., if B → γ is a production, we add B → ·γ in the closure

Example

Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b

Example

Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b

I_0:

S’ → ·S

Example

Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b

I_0:

S’ → ·S

S → ·BB

Example

Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b

I_0:

S’ → ·S

S → ·BB

B → ·aB

B → ·b

Example

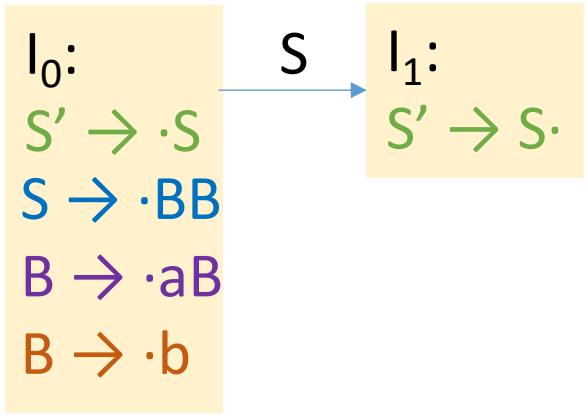
Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b



Example

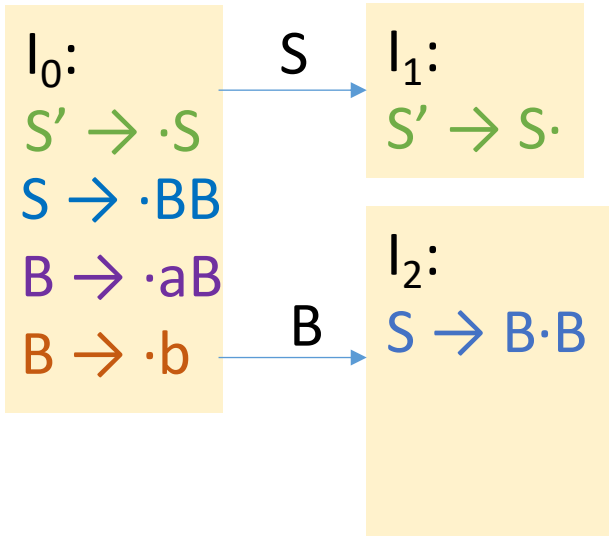
Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b



Example

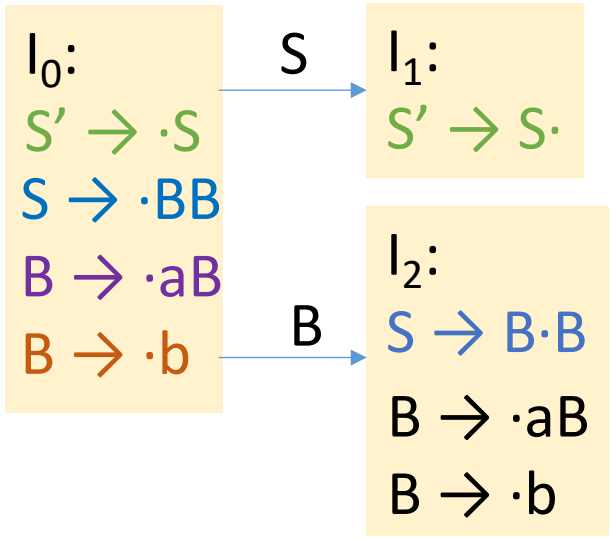
Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b



Example

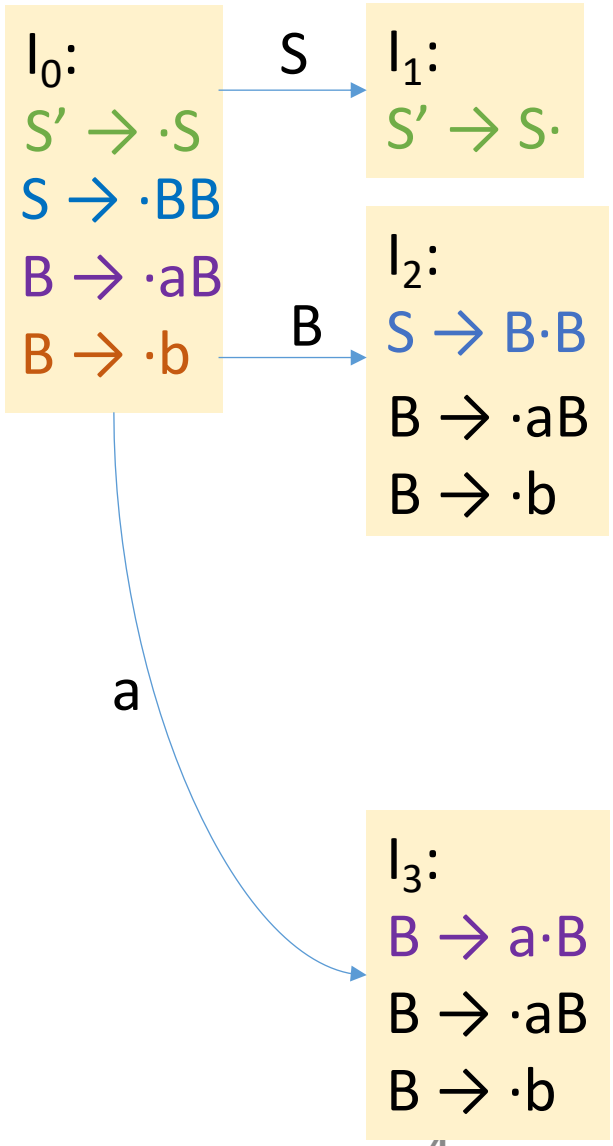
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example

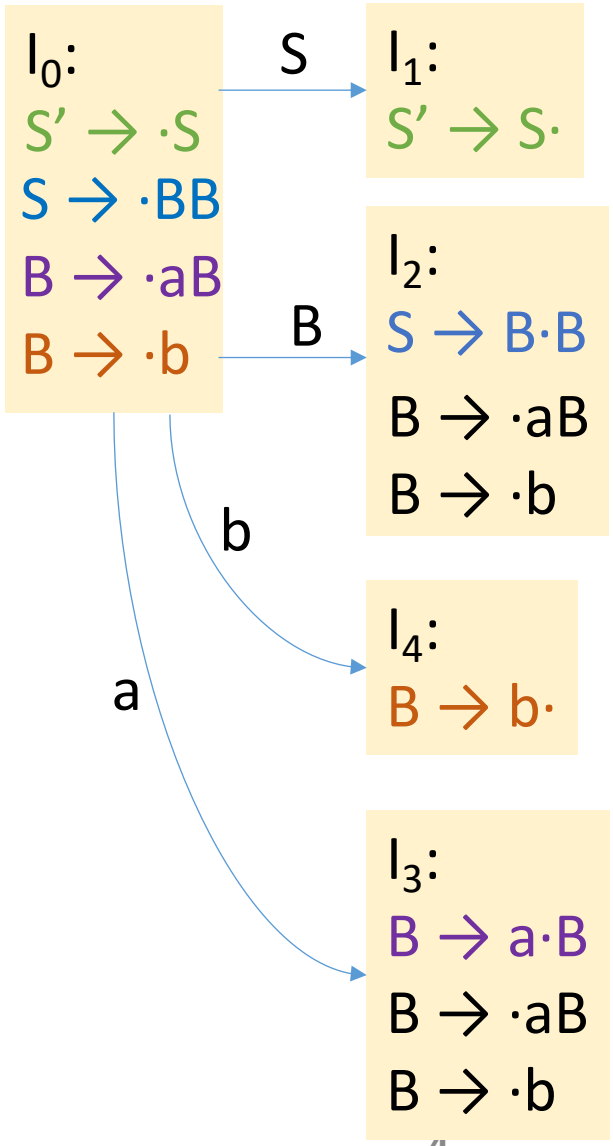
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example

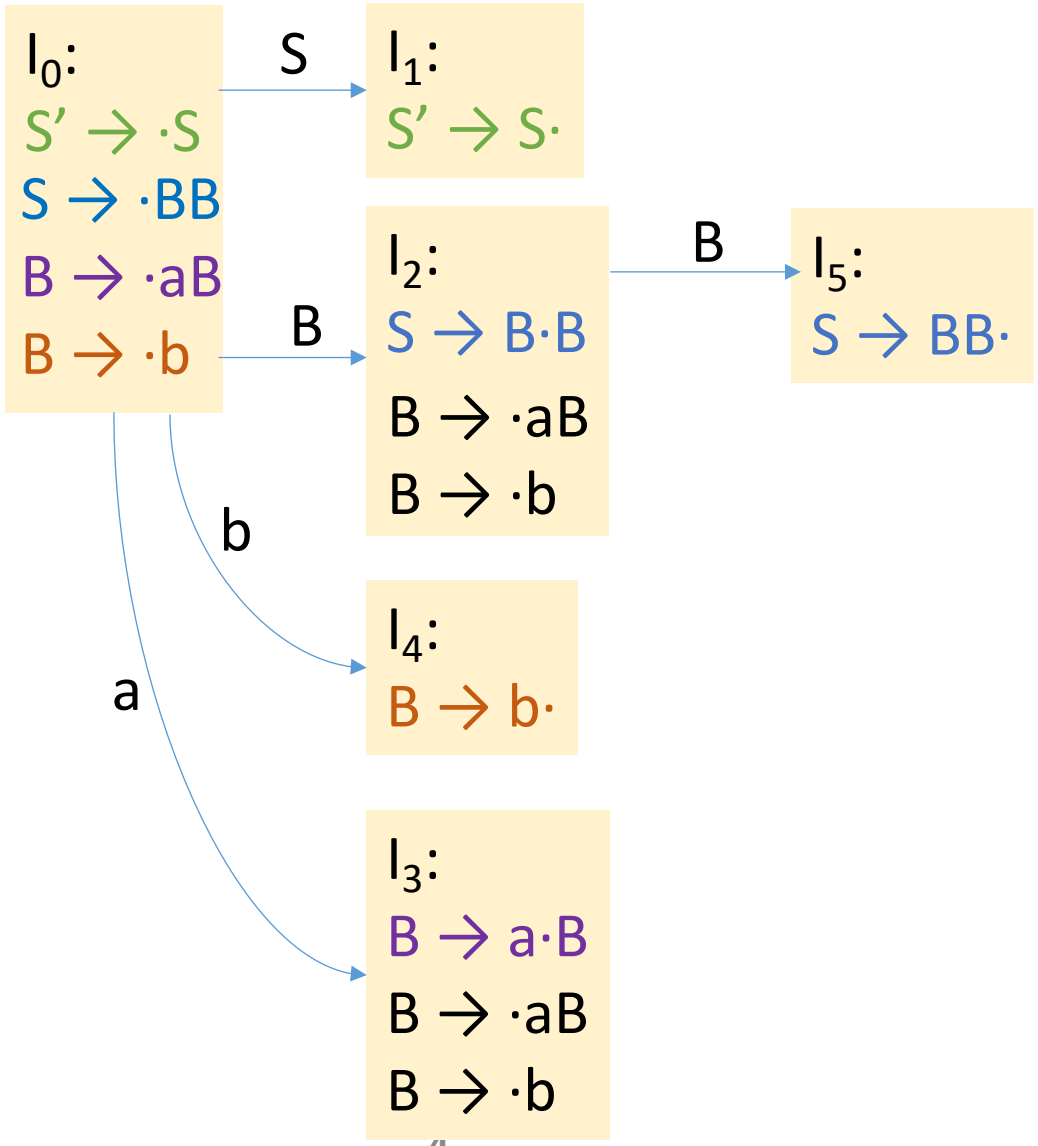
Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b



Example

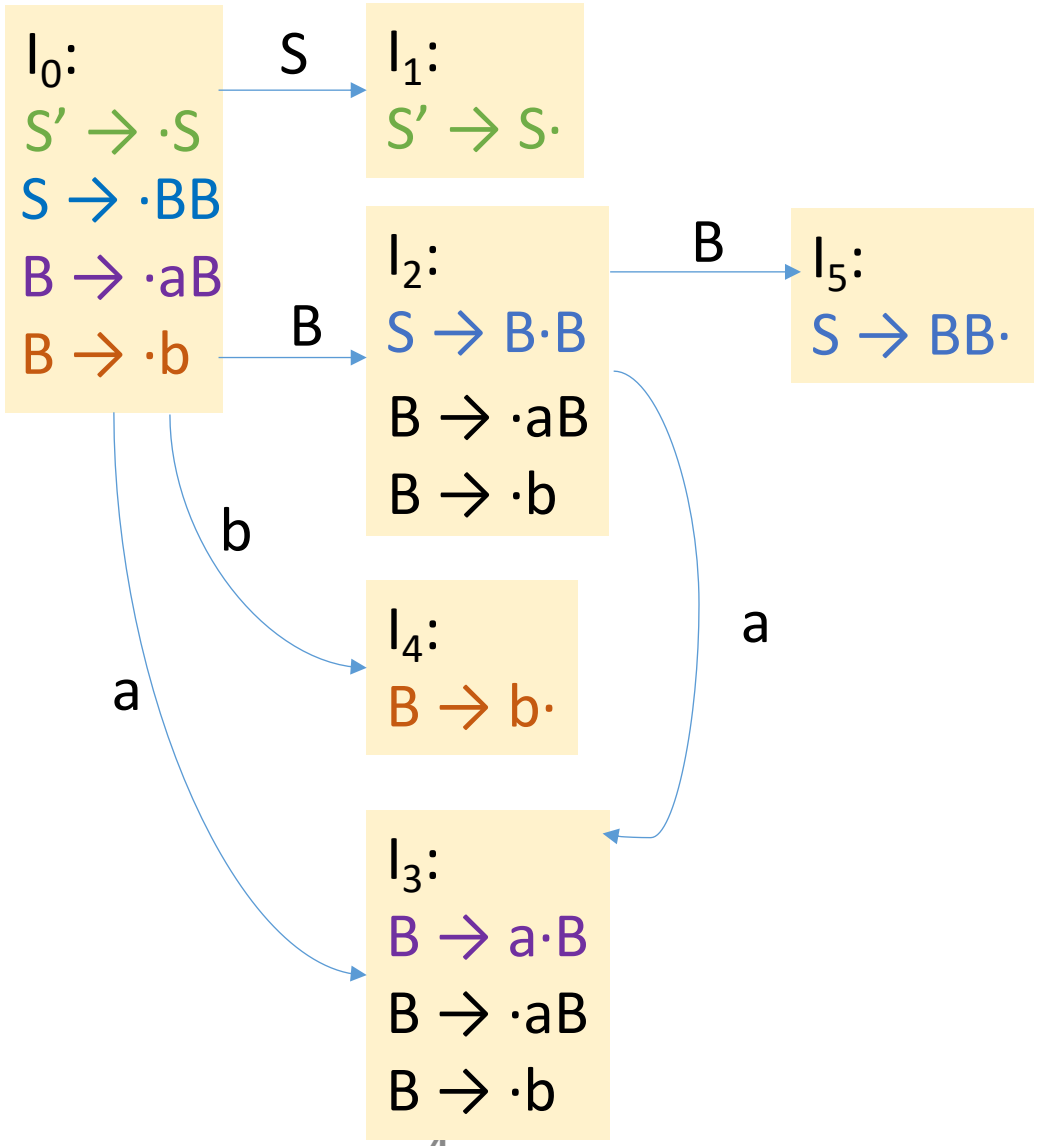
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example

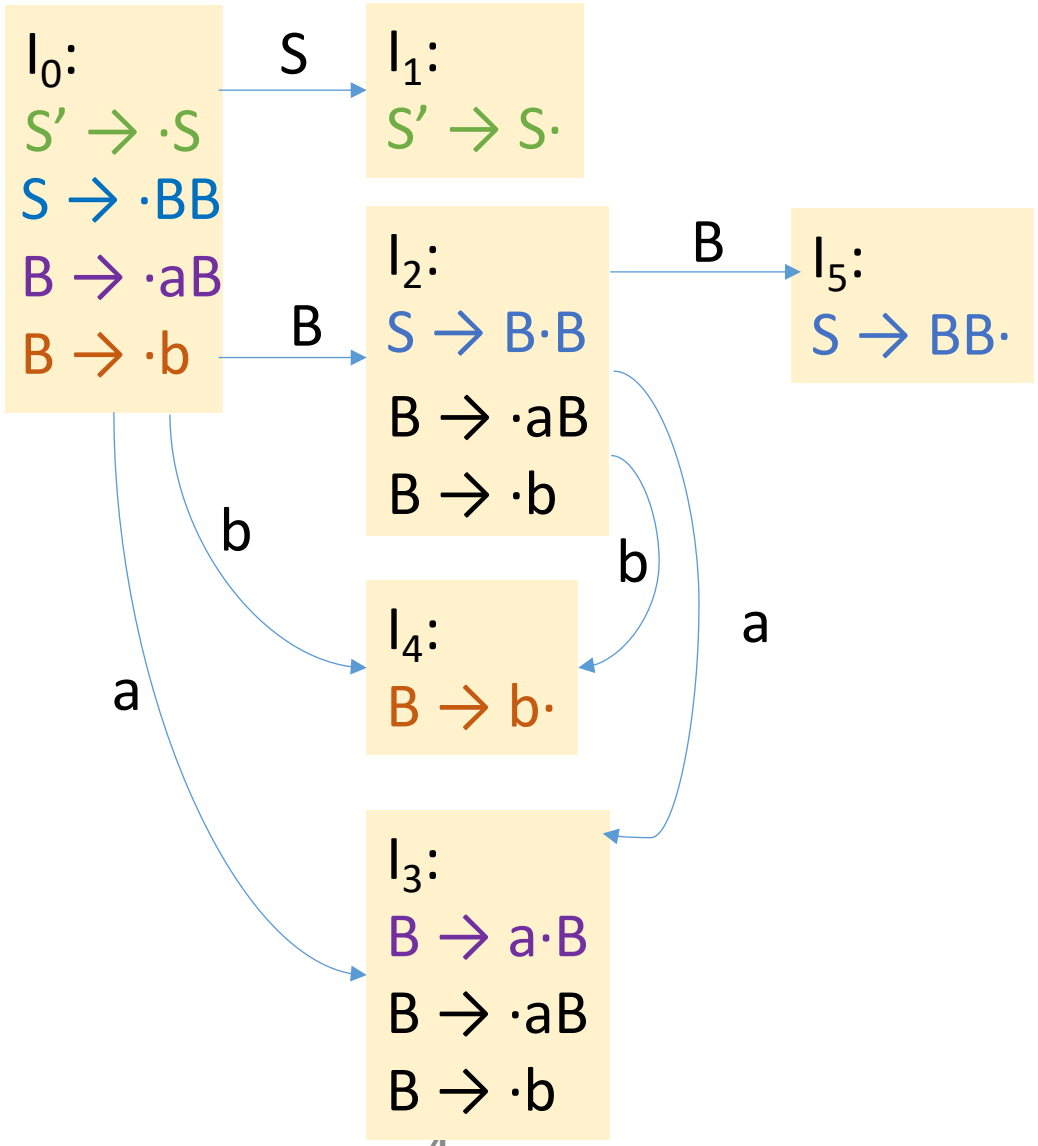
Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b



Example

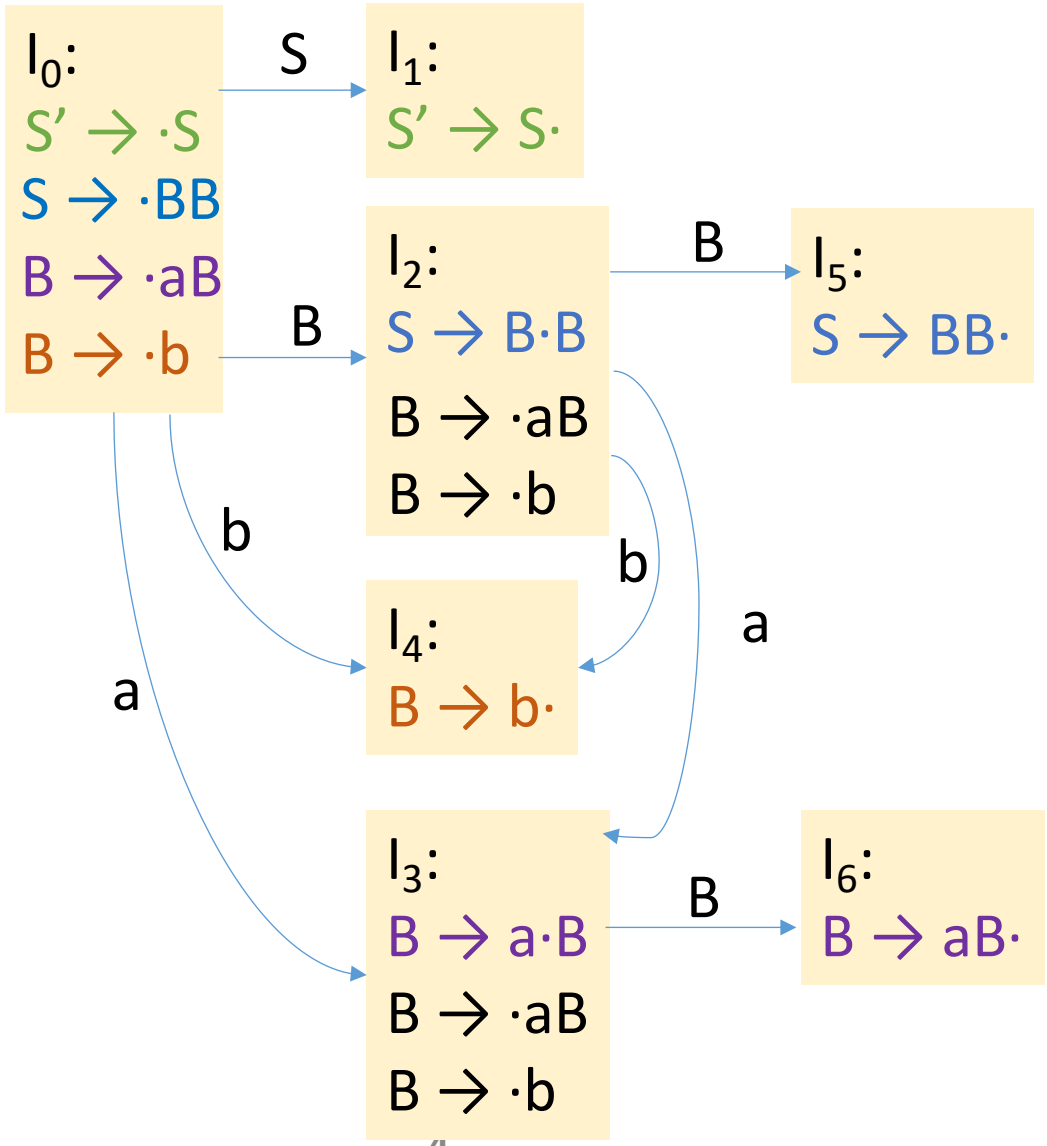
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example

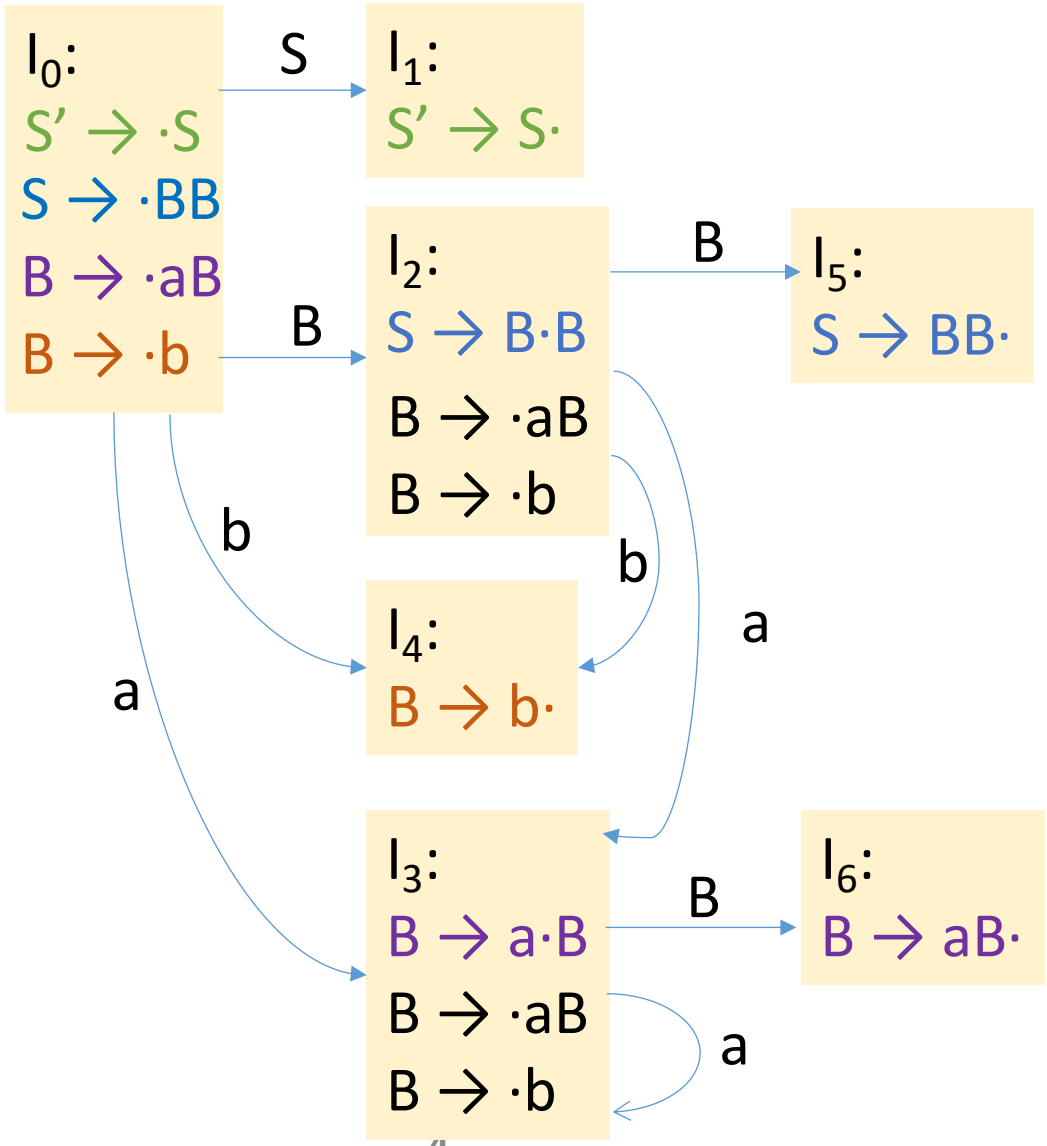
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example

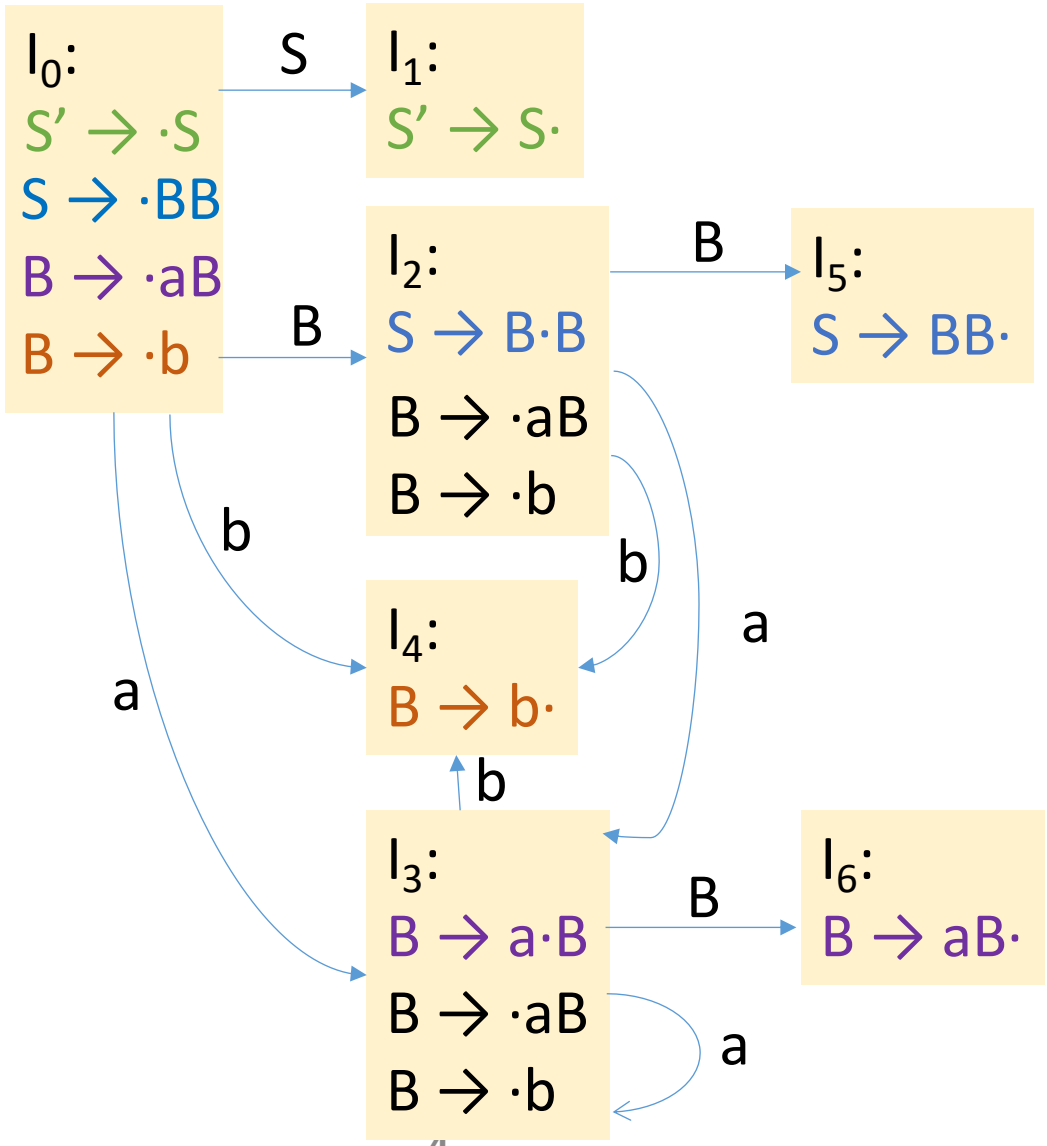
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example

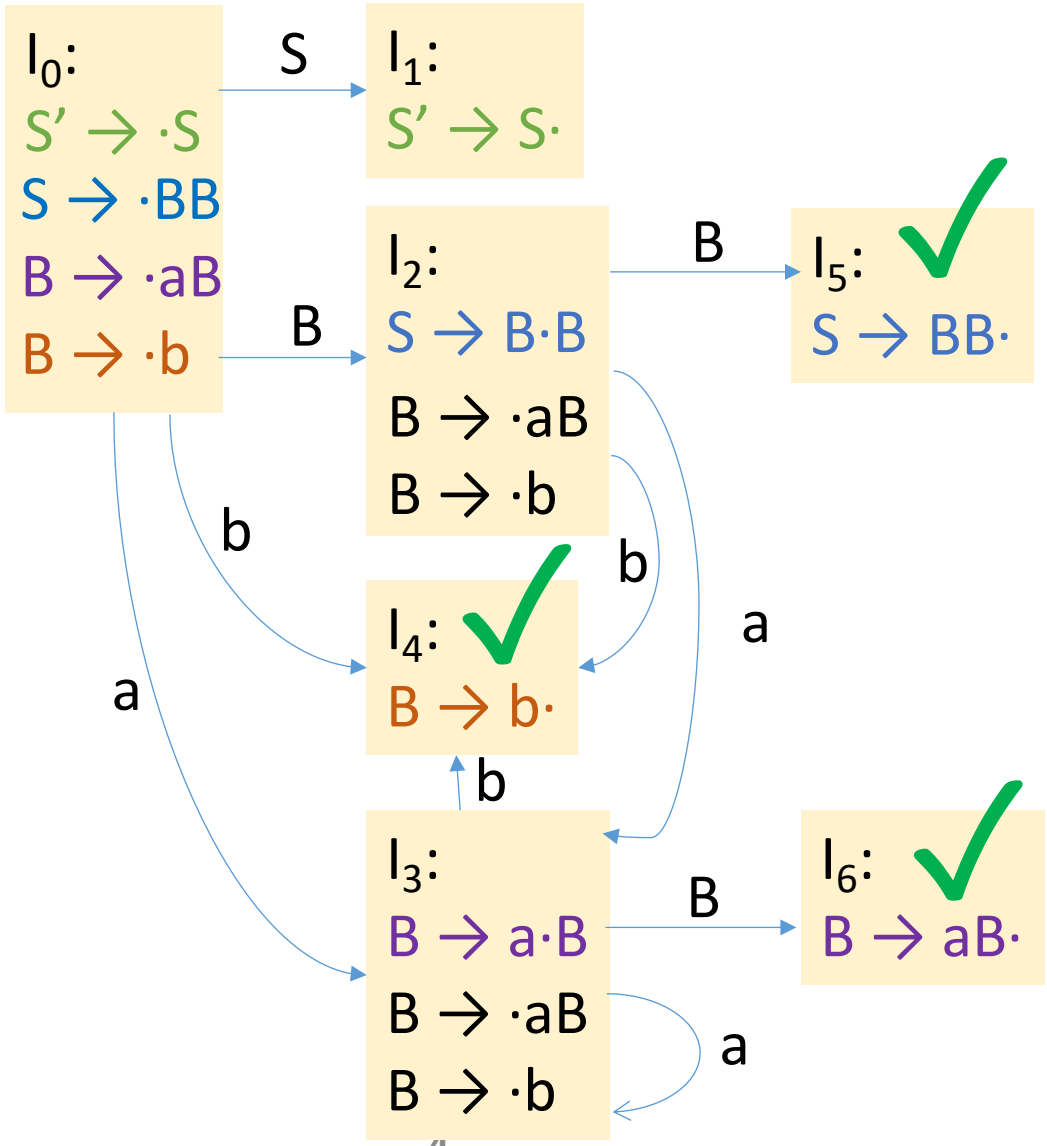
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



Example (cont.)

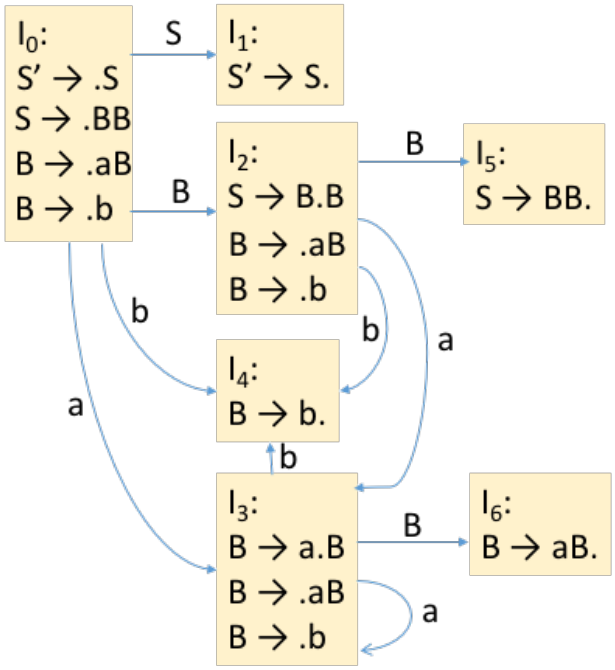
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

Example (cont.)

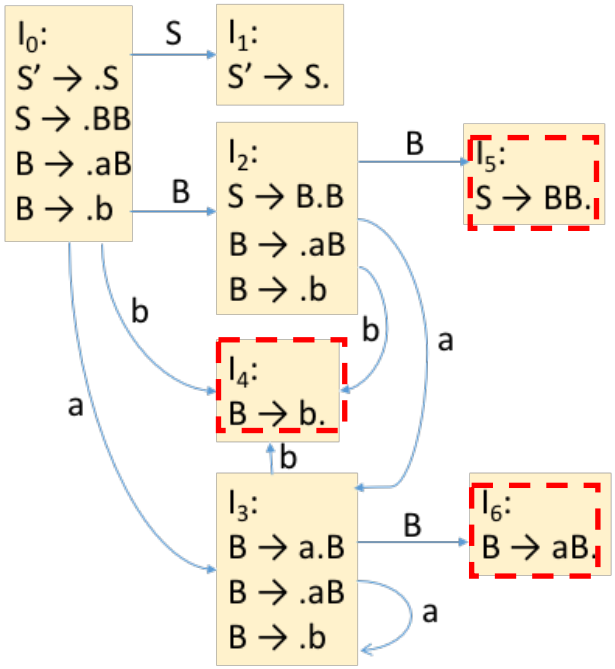
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

Example (cont.)

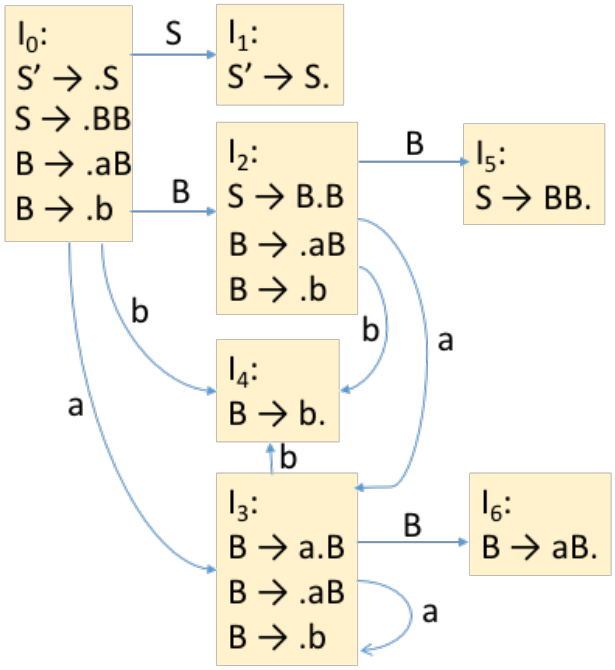
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

Example (cont.)

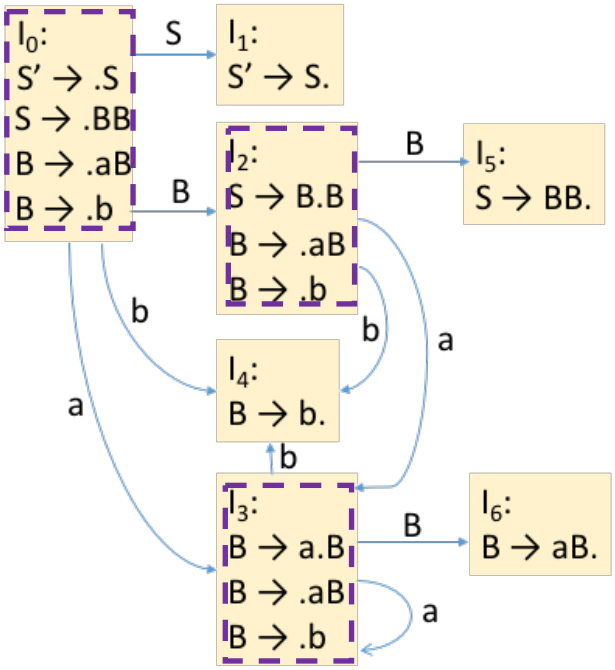
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

Example (cont.)

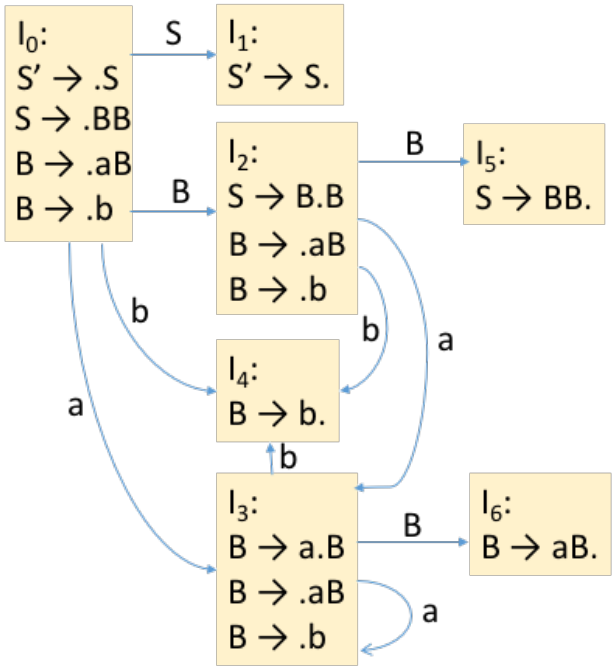
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

Example (cont.)

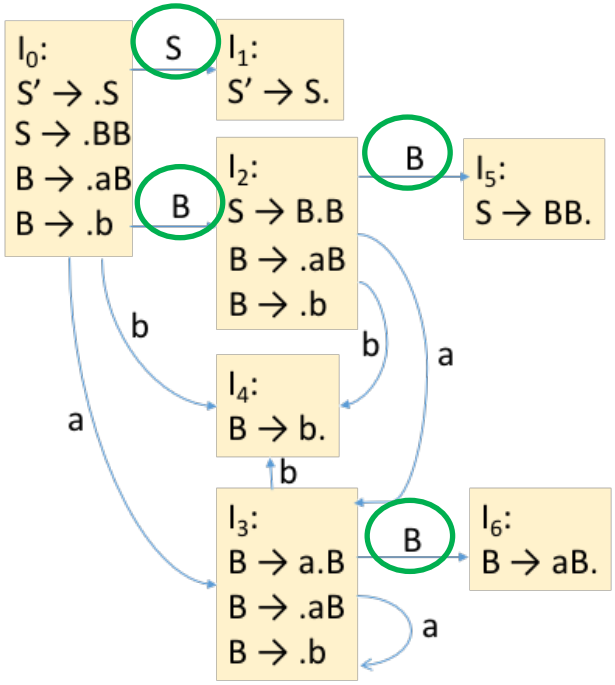
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

Example (cont.)

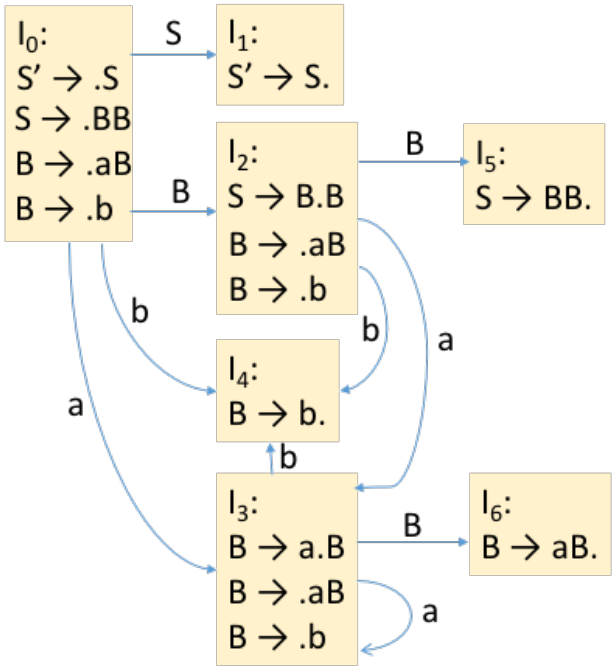
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

"state *j*" refers to the state corresponding to the set of items I_j

CLOSURE()[闭包]

- **Closure of item sets**: if *I* is a set of items for a grammar *G*, then *closure(I)* is the set of items constructed from *I* by the two rules:
  - Initially, add every item in *I* to *CLOSURE(I)*
  - If A → α·Bβ is in *CLOSURE(I)* and B → γ is a production, then add item B → ·γ to *CLOSURE(I)*, if it is not already there[期待B]
    - Apply this rule until no more new items can be added to *CLOSURE(I)*

Grammar:

(0) S’ → S

(1) S → BB

(2) B → aB

(3) B → b

S’ → ·S

S’ → ·S

S → ·BB

B → ·aB

B → ·b

goto()[跳转]

- goto(*I*, *X*): returns state (i.e., set of items) that can be reached by advancing X
  - Where *I* is a set of items and *X* is a grammar symbol
  - The closure of the set of all items [A → αX·β] such that [A → α·Xβ] is in *I*[即：识别了/归约到X后的item再闭包]
  - Used to define the transitions in the LR(0) automaton[定义了状态间的转换]
    - The states of the automaton correspond to sets of items, and goto(I, X) specifies the transition from the state for *I* under input *X*

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

I_0:

S' → ·S

S → ·BB

B → ·aB

B → ·b

goto()[跳转]

- goto(*I*, *X*): returns state (i.e., set of items) that can be reached by advancing X
  - Where *I* is a set of items and *X* is a grammar symbol
  - The closure of the set of all items [A → αX·β] such that [A → α·Xβ] is in *I*[即：识别了/归约到X后的item再闭包]
  - Used to define the transitions in the LR(0) automaton[定义了状态间的转换]
    - The states of the automaton correspond to sets of items, and goto(I, X) specifies the transition from the state for *I* under input *X*

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

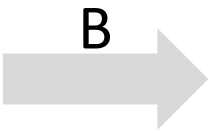
I_0:

S' → ·S

S → ·BB

B → ·aB

B → ·b



goto()[跳转]

- goto(*I*, *X*): returns state (i.e., set of items) that can be reached by advancing X
  - Where *I* is a set of items and *X* is a grammar symbol
  - The closure of the set of all items [A → αX·β] such that [A → α·Xβ] is in *I*[即：识别了/归约到X后的item再闭包]
  - Used to define the transitions in the LR(0) automaton[定义了状态间的转换]
    - The states of the automaton correspond to sets of items, and goto(I, X) specifies the transition from the state for *I* under input *X*

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

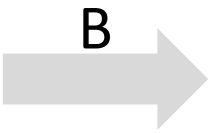
I_0:

S' → ·S

S → ·BB

B → ·aB

B → ·b



goto()[跳转]

- goto(*I*, *X*): returns state (i.e., set of items) that can be reached by advancing X
  - Where *I* is a set of items and *X* is a grammar symbol
  - The closure of the set of all items [A → αX·β] such that [A → α·Xβ] is in *I*[即：识别了/归约到X后的item再闭包]
  - Used to define the transitions in the LR(0) automaton[定义了状态间的转换]
    - The states of the automaton correspond to sets of items, and goto(I, X) specifies the transition from the state for *I* under input *X*

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

I_0:

S' → ·S

S → ·BB

B → ·aB

B → ·b

I_2:

S → B·B

goto()[跳转]

- goto(*I*, *X*): returns state (i.e., set of items) that can be reached by advancing X
  - Where *I* is a set of items and *X* is a grammar symbol
  - The closure of the set of all items [A → αX·β] such that [A → α·Xβ] is in *I*[即：识别了/归约到X后的item再闭包]
  - Used to define the transitions in the LR(0) automaton[定义了状态间的转换]
    - The states of the automaton correspond to sets of items, and goto(I, X) specifies the transition from the state for *I* under input *X*

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

I_0:

S' → ·S

S → ·BB

B → ·aB

B → ·b

I_2:

S → B·B

B → ·aB

B → ·b

Construct LR(0) States

- [增广文法]Create augmented grammar G' for G
  - Given G: S → α | β, create G': S' → S S → α | β
  - Creates a single rule S' → S that when reduced, signals acceptance
- [初始状态]Create 1st state by performing a closure on initial item S'→ ·S
  - Closure(I): creates state from an initial set of items I
  - Closure({S'→ ·S}) = {S'→ ·S, S → ·α, S → ·β}
- [添加状态]Create additional states by performing a **goto** on each symbol
  - Goto(I, X): creates state that can be reached from I by advancing X
  - If α was single symbol, the following new state would be created:
    Goto({S'→ ·S, S → ·α, S → ·β}, α) =
    Closure({S → α·}) = {S → α·}
- [重复操作]Repeatedly perform gotos until there are no more states to add

Construct DFA

- Compute canonical LR(0) collection[规范LR(0)项集族, C], i.e., set of all states in DFA
  - One collection of sets of LR(0) items provides the basis for constructing a DFA that is used to make parsing decisions
  - Such an automaton is called an **LR(0) automaton**[LR(0)自动机]
    - Each state of the LR(0) automaton represents a set of items in the C
- All new states are added through goto(I, X)
  - State transitions are done on symbol X

```
void items(G') {                        // G': the augmented grammar
   C = { CLOSURE({[S' → ·S]}) }; // C: the canonical collection of sets of LR(0) items
   repeat
      for ( each state I in C )
            for ( each grammar symbol X )
               if ( goto(I, X) is not empty and not in C)
                  add goto(I, X) to C;
    until no new states are added to C
}
```

LR(0) Automaton[自动机]

- The LR(0) automaton: each time we perform a shift we are following a transition to a new state[移入：到新状态]
  - States: the sets of items in C
    - Start state: CLOSURE({[S' → ·S]})
    - State *j* refers to the state corresponding to the set of items I_j
  - Transitions are given by the goto() function
- How can the automaton help with shift-reduce decisions?
  - Suppose that the string γ of grammar symbols takes the LR(0) automaton from the start state *0* to some state *j*
  - Then, shift on next input symbol *a* if state *j* has a transition on *a*
  - Otherwise, we choose to reduce
    - The items in state *j* tell us which production to use (e.g., $E \rightarrow \alpha$)
    - $E \rightarrow \alpha$: pop states for α, bringing state *x* to the top and look for a transition on *E* to state *y* (i.e., state *x* has a transition on *E* to state *y*), which is then pushed to stack

The Example

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

- S_0 = Closure({S' → .S})
  = {S' →.S, S →.BB, B → .aB, B → .b}
- Goto(S_0, B) = closure({S → B.B})
  S_2 = {S →B.B, B → .aB, B → .b}
- Goto(S_0, a) = closure({B → a.B})
  S_3 = {B →a.B, B → .aB, B → .b}
- Goto(S_0, b) = closure({B → b.})
  S_4 = {B → b.}

… … …

The Example

Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b

- S_0 = Closure({S' → .S})

  = {S' →.S, S →.BB, B → .aB, B → .b}

- Goto(S_0, B) = closure({S → B.B}) S_2

  = {S →B.B, B → .aB, B → .b}

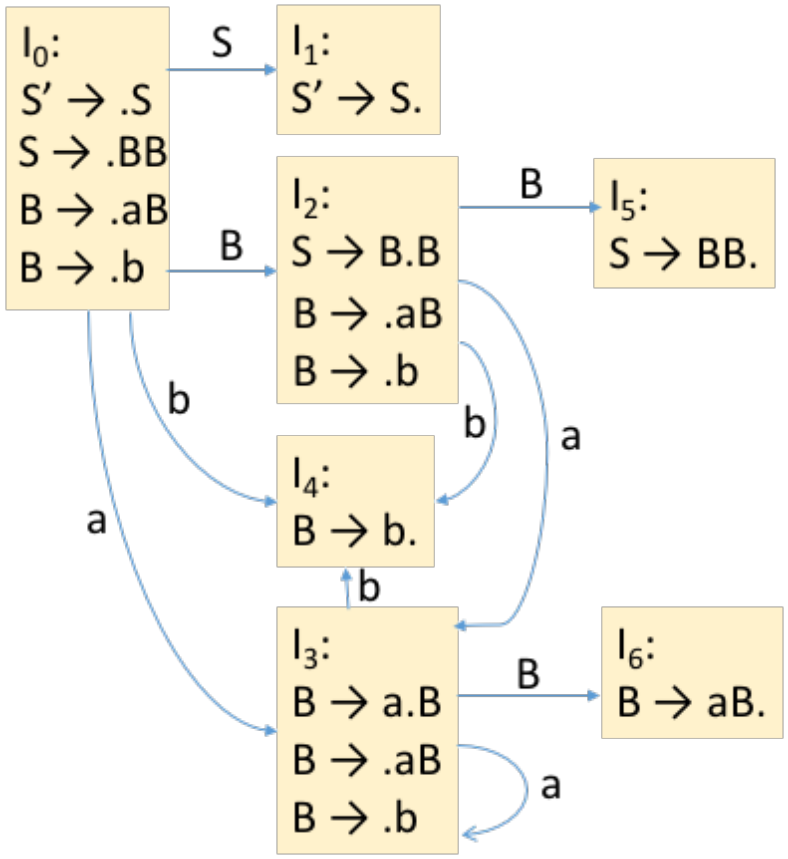
- Goto(S_0, a) = closure({B → a.B}) S_3

  = {B →a.B, B → .aB, B → .b}

- Goto(S_0, b) = closure({B → b.}) S_4

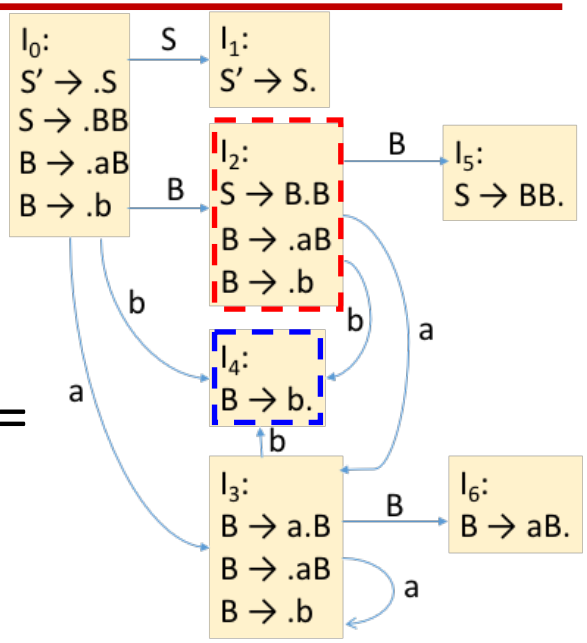
  = {B → b.}

… … …



Build Parse Table from DFA

- ACTION: [*state*, *terminal symbol*]
- GOTO: [*state*, *non-terminal symbol*]
- ACTION[动作]
  - If [A→α·aβ] is in S_i and goto(S_i, a) = S_j, where "a" is a terminal, then ACTION[S_i, a] = shift j (*sj*)
  - If [A→α·] is in S_i and A→α is rule numbered j, then ACTION[S_i, a] = reduce j (*rj*)
  - If [S' →S·] is in S_i then ACTION[S_i, $] = accept
  - If no conflicts among 'shift' and 'reduce' (the first two 'if's), then this parser is able to parse the given grammar
- GOTO[跳转]
  - if goto(S_i, A) = S_j then GOTO[S_i, A] = *j*
- All entries not filled are rejects



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

The Example

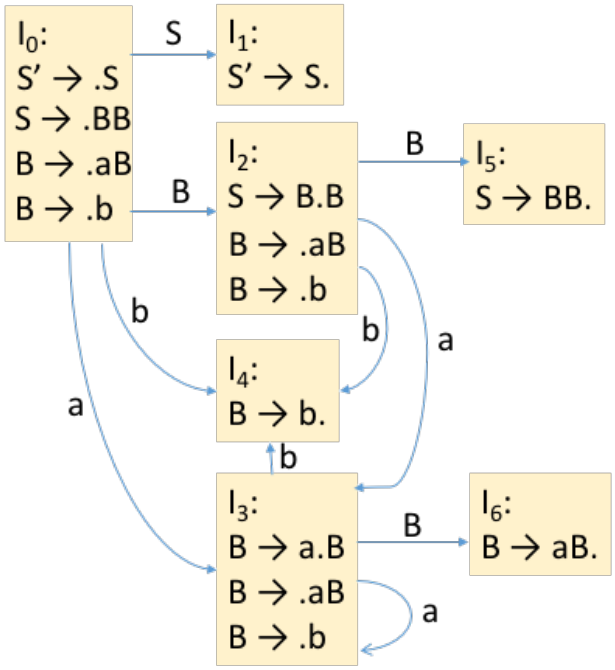
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

The Example

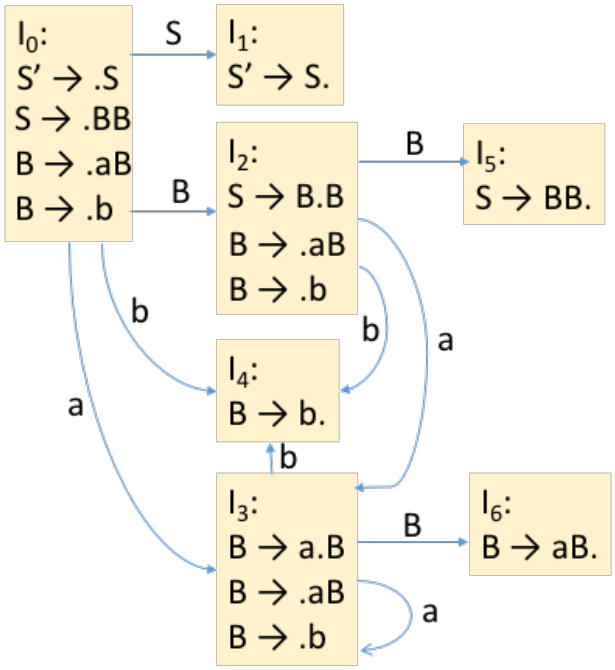
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

The Example

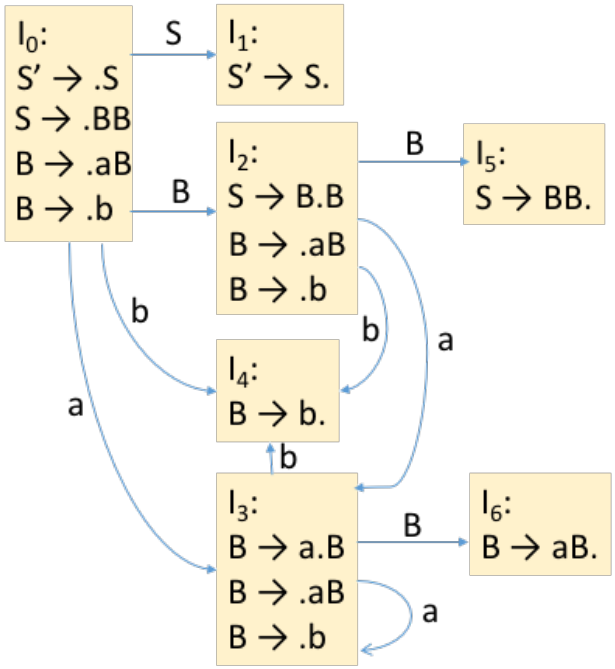
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

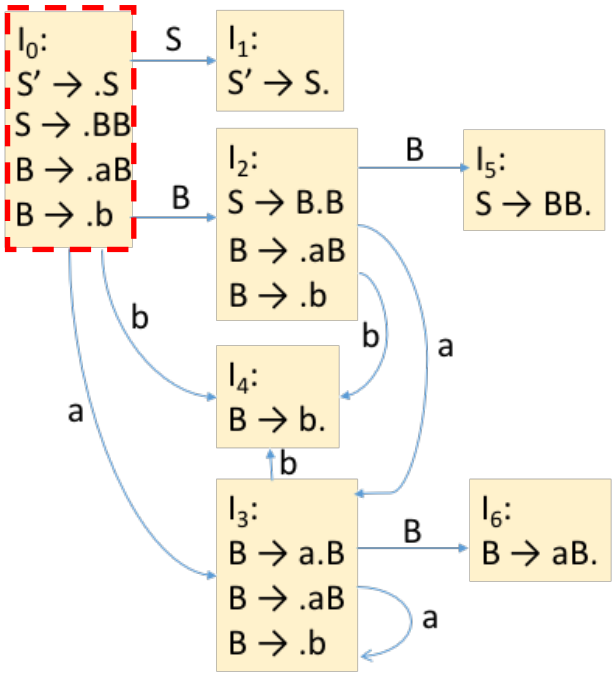
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

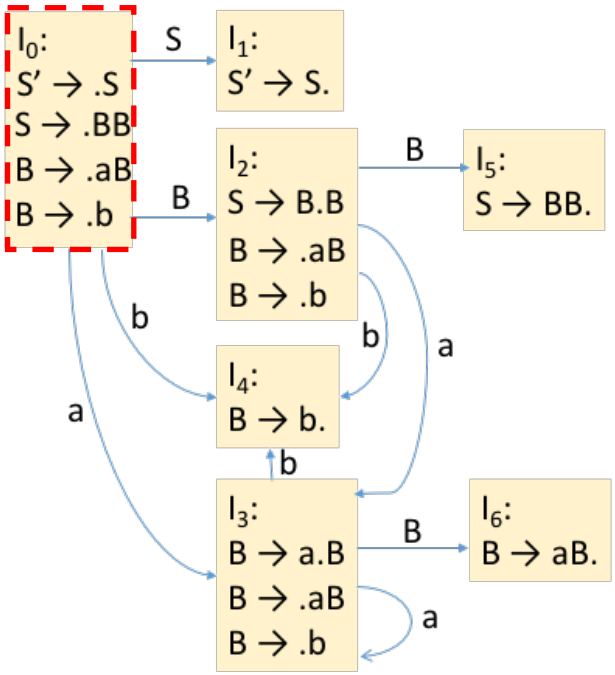
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

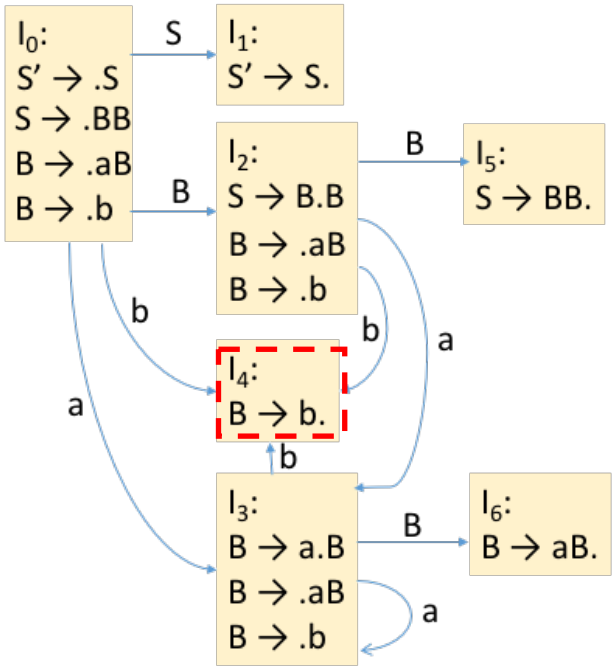
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

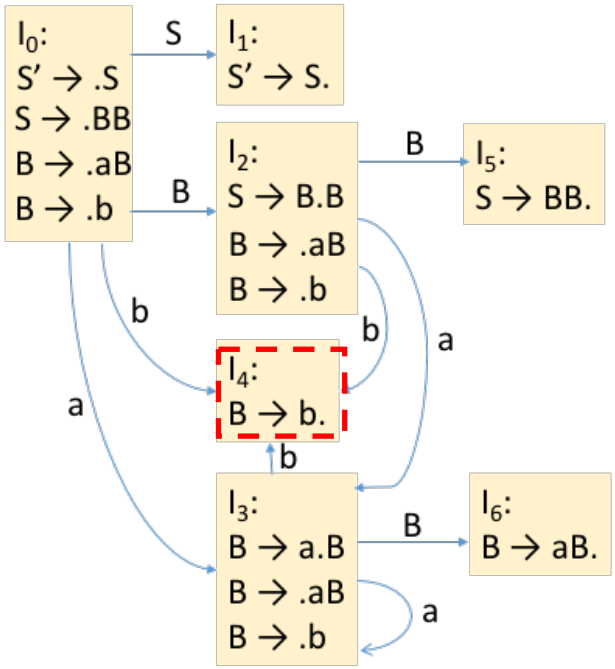
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

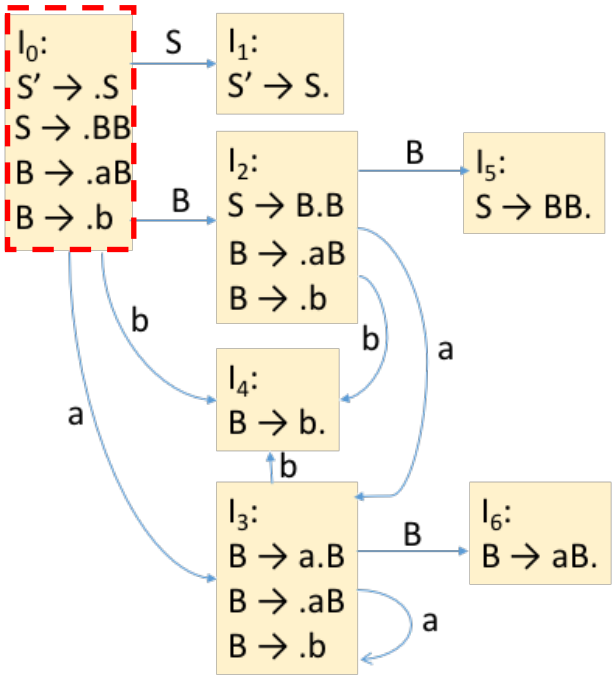
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

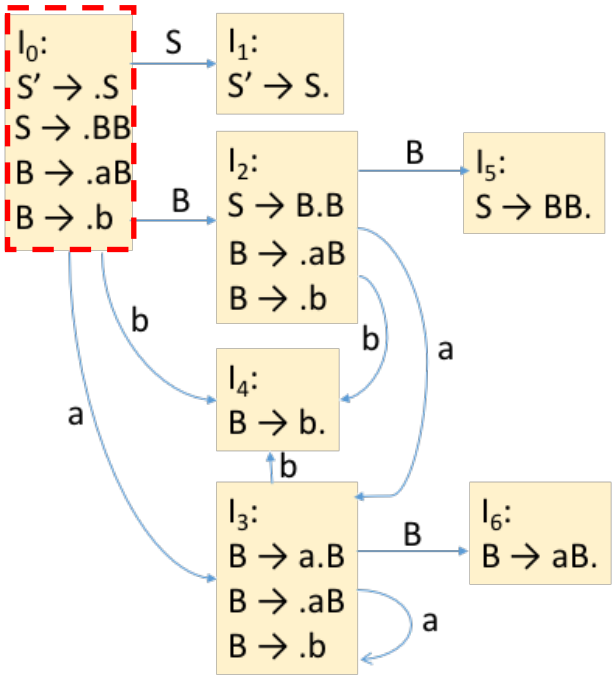
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

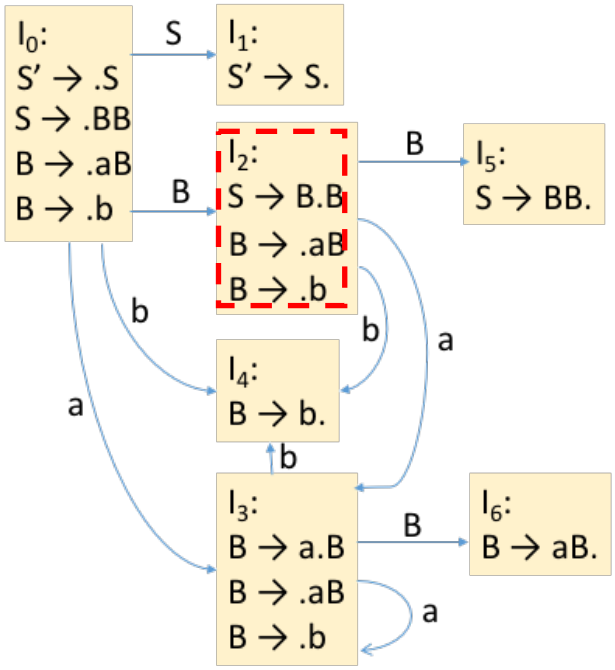
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

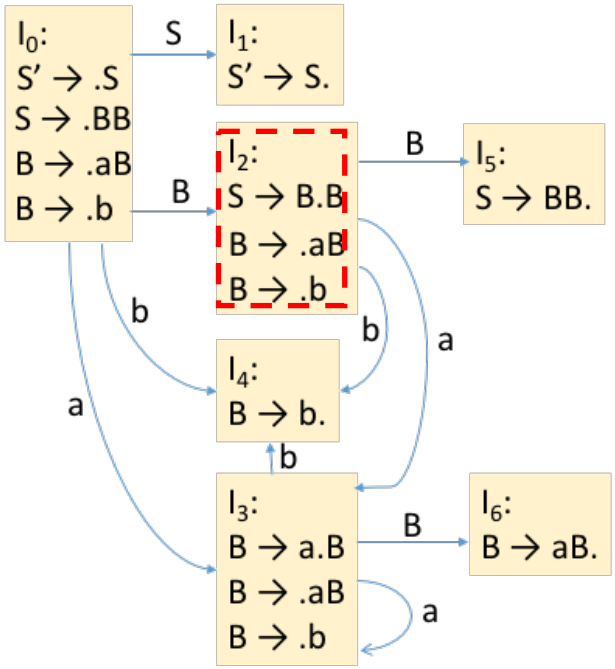
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

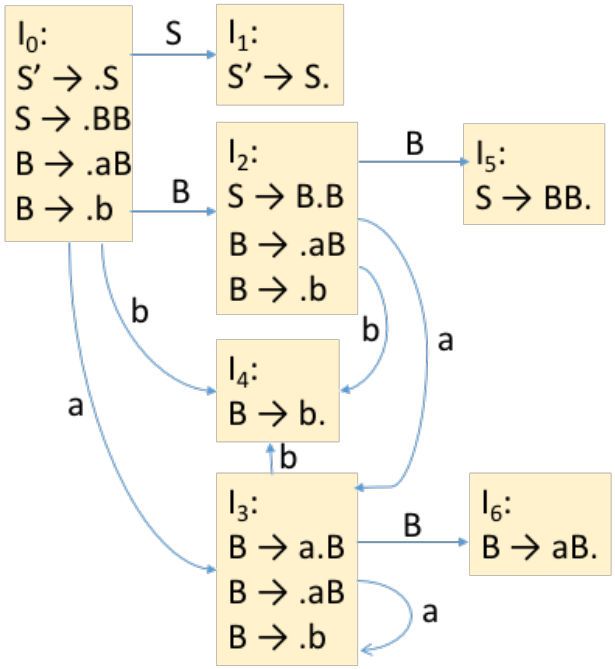
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

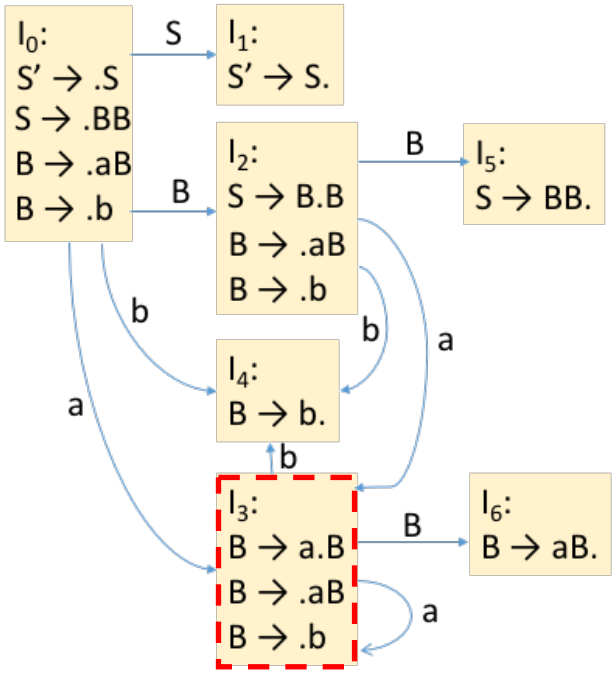
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

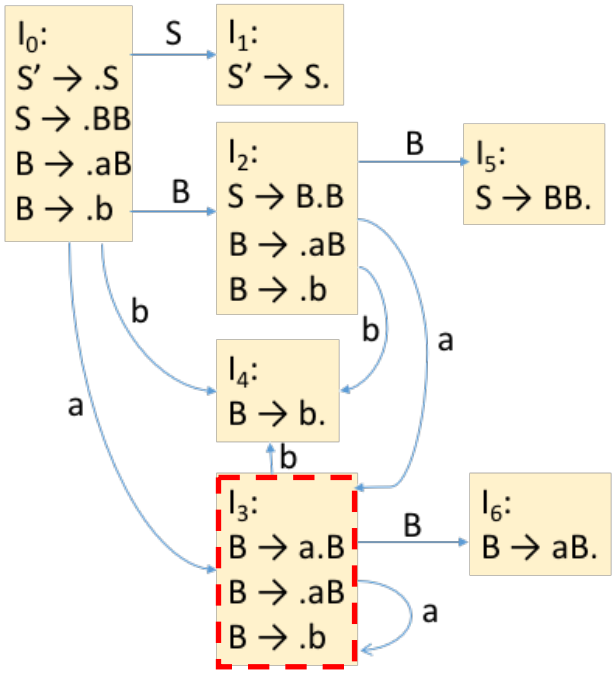
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

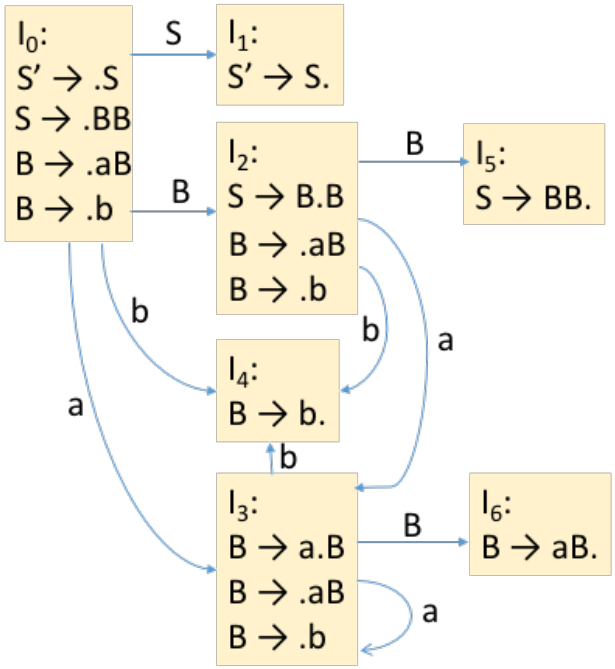
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

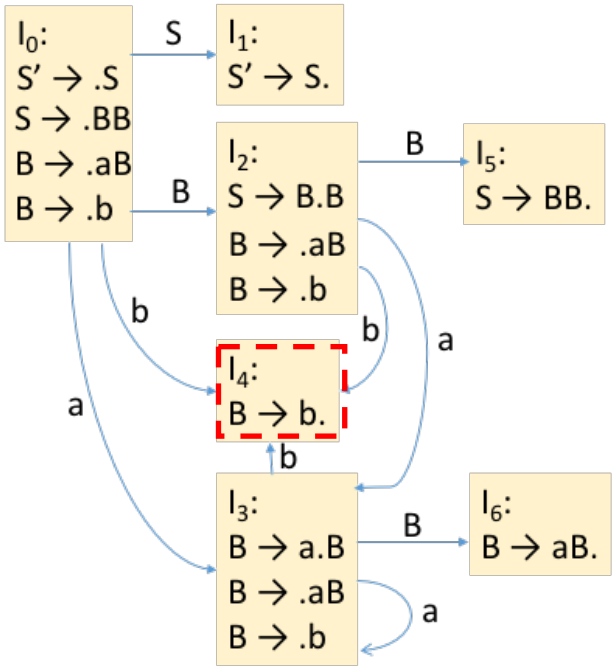
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

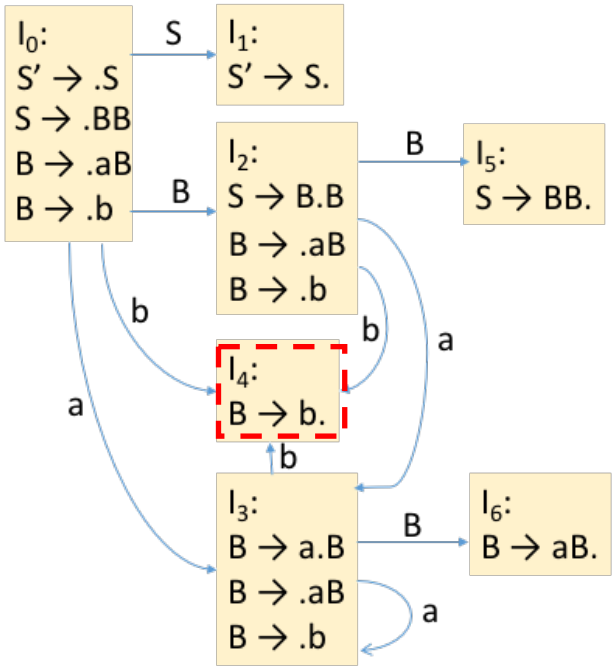
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4

The Example

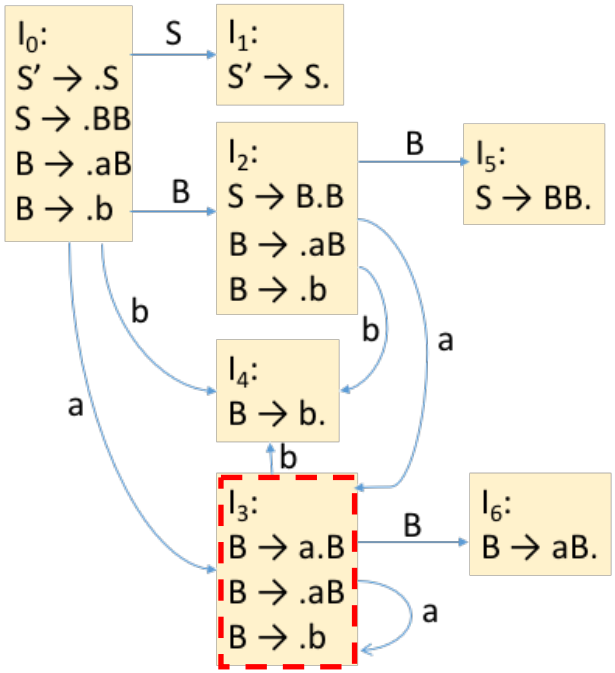
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4

The Example

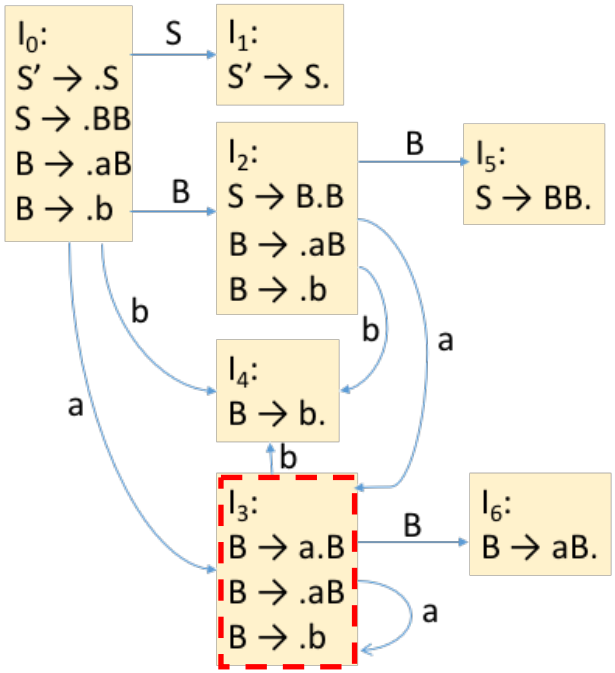
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3

The Example

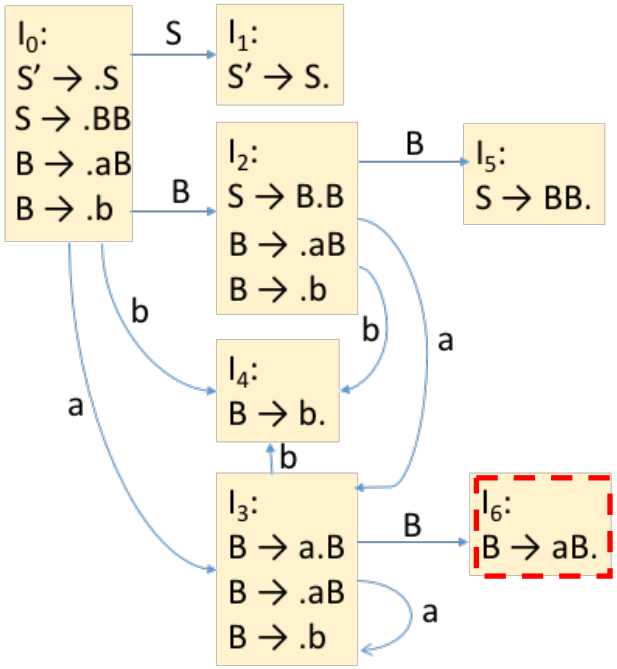
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3

The Example

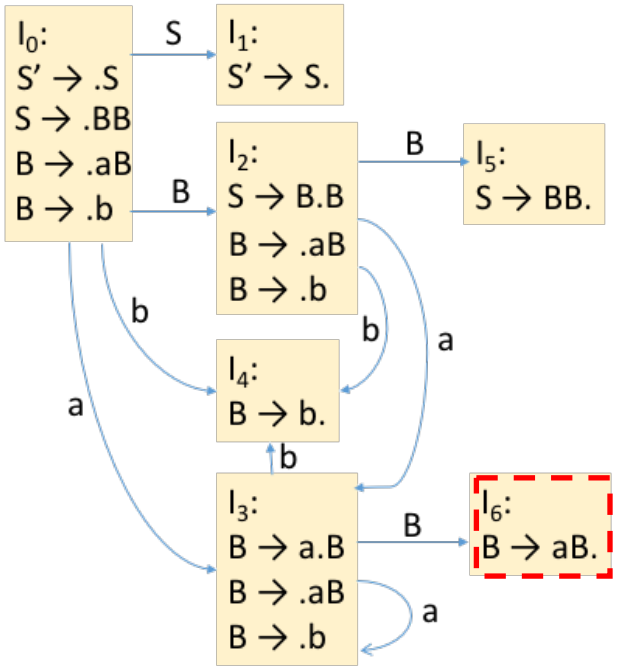
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6

The Example

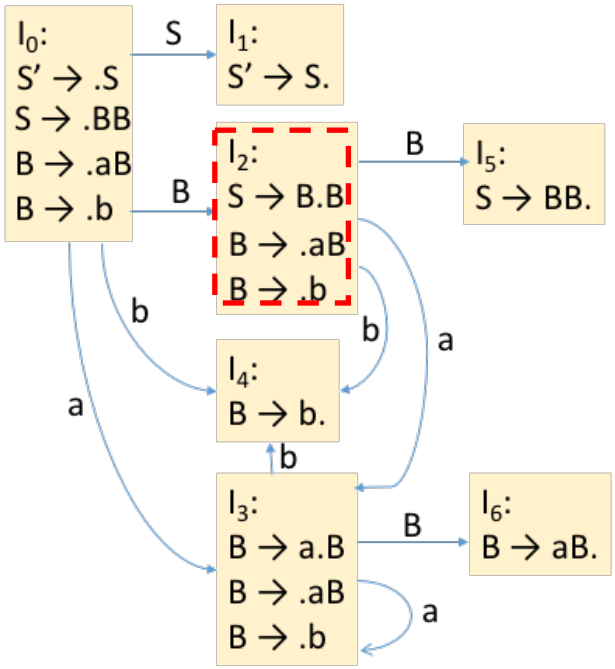
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6

The Example

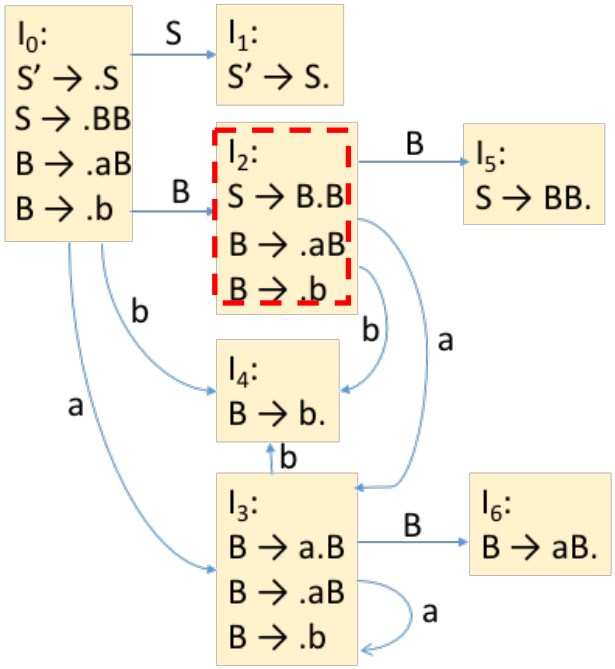
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2

The Example

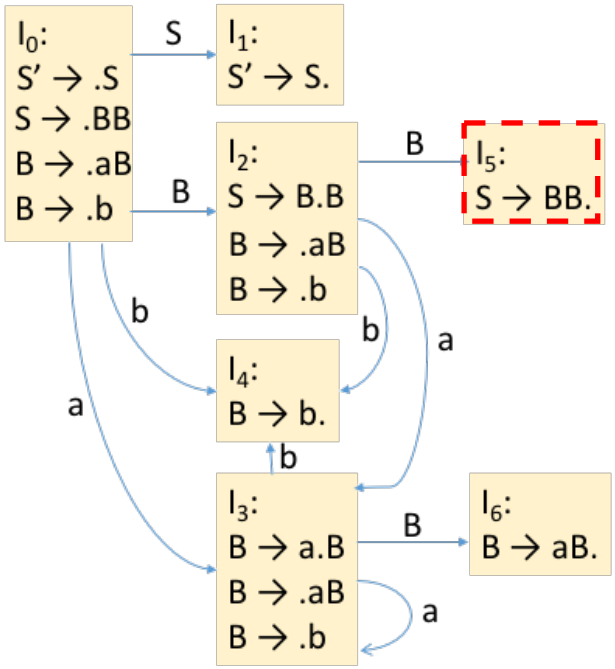
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2

The Example

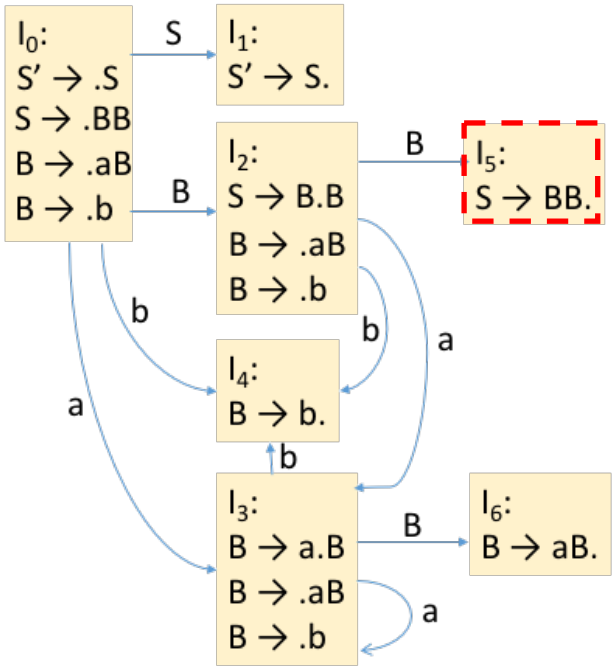
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2 5

The Example

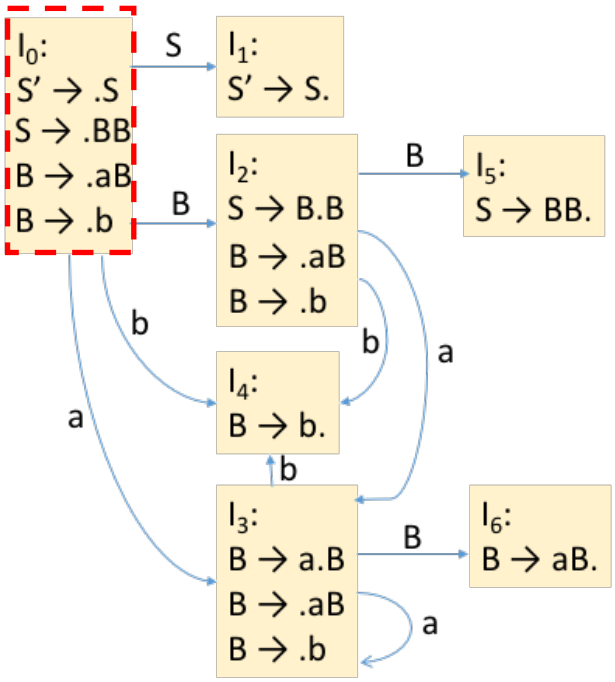
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2 5

The Example

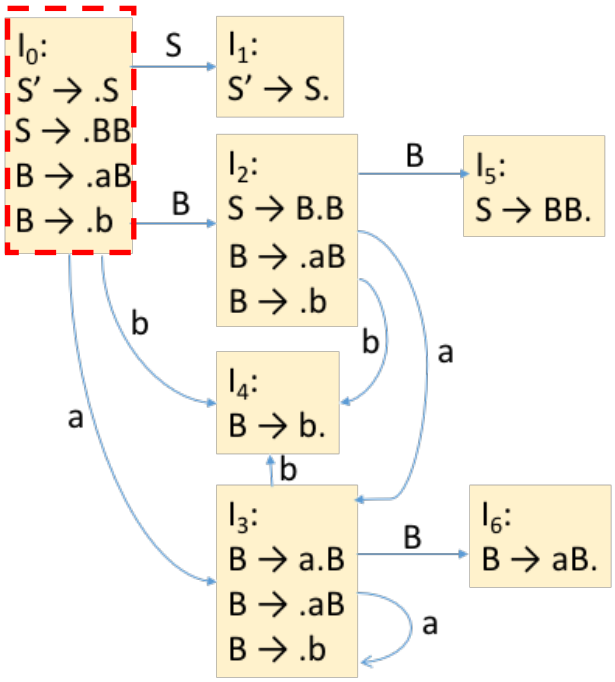
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2 5 0

The Example

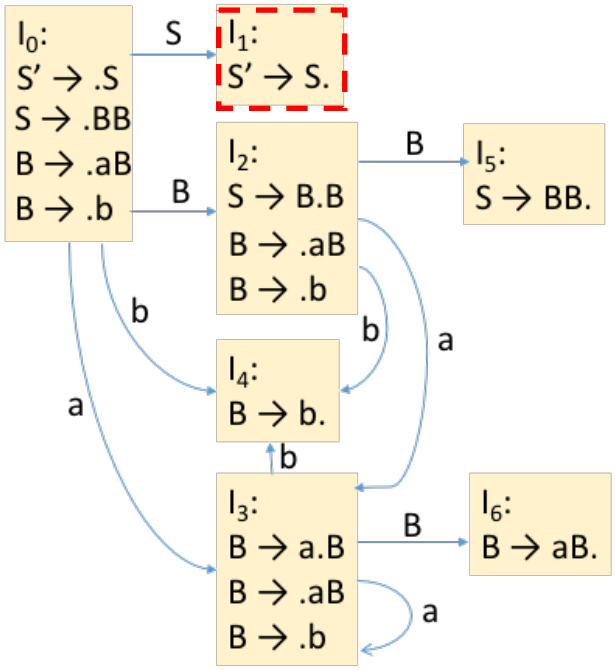
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2 5 0

The Example

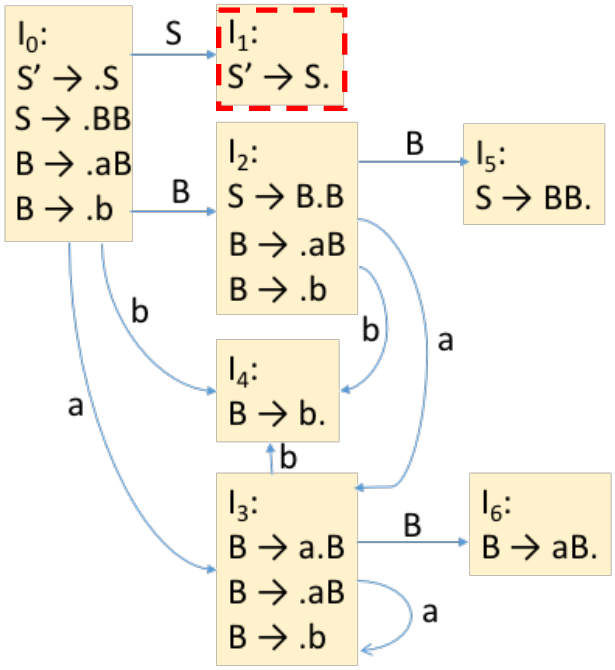
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2 5 0 1

The Example

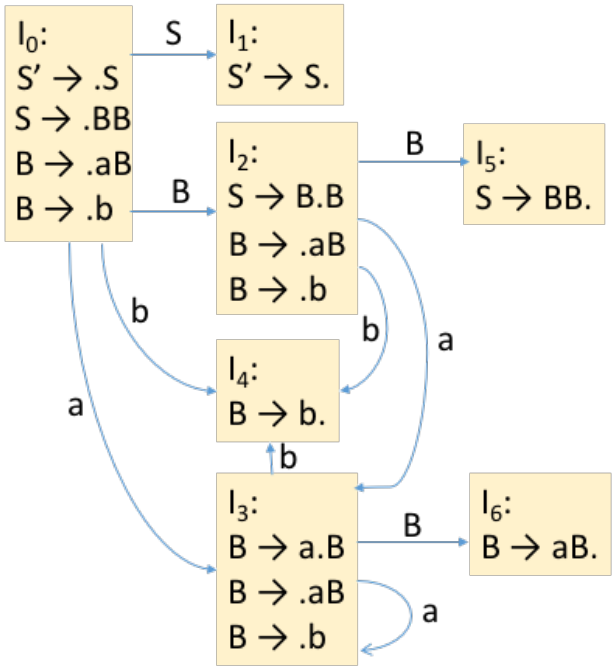
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

0 0 4 0 2 0 2 3

=> Bab#$ => BaB#$ => BB#$ => S#$

0 2 3 4 0 2 3 6 0 2 5 0 1

The Example

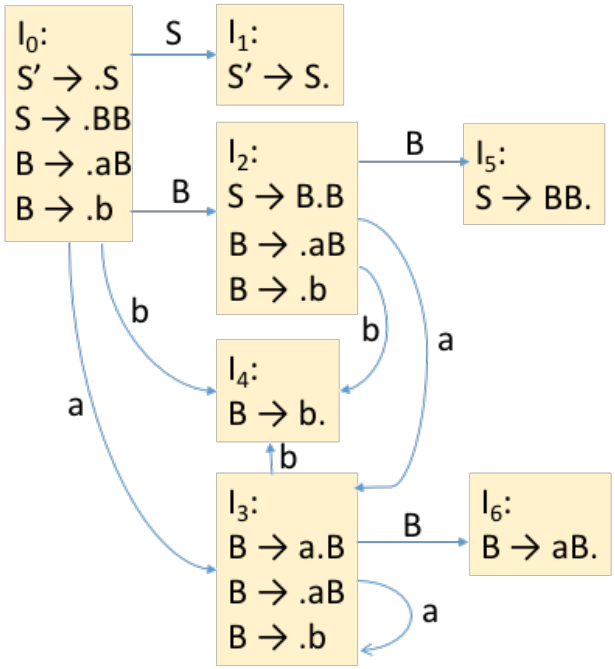
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

String: bab

#bab$ => b#ab$ => B#ab$ => Ba#b$

=> Bab#$ => BaB#$ => BB#$ => S#$

The Example

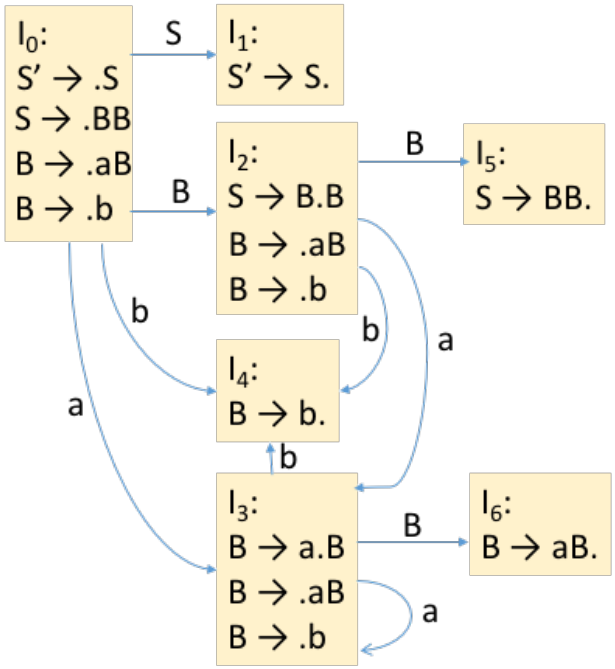
Grammar:

(0) S' → S

(1) S → BB

(2) B → aB

(3) B → b



State	ACTION			GOTO	
	a	b	$	S	B
0	s3	s4		1	2
1			acc		
2	s3	s4			5
3	s3	s4			6
4	r3	r3	r3		
5	r1	r1	r1		
6	r2	r2	r2		

☆ 是LR(0)，没有任何lookahead ☆

- state直接决定了是shift/reduce，并不需要看输入符号
- 若reduce，输入符号及整个input buffer没有任何变化
- 若shift，输入符号从input buffer移入stack

LR(0) Parsing

- Construct LR(0) automaton from the Grammar[由文法构建自动机]
- Idea: assume
  - Input buffer contains α[但buffer不止有α]
  - Next input is *t*[α后是t]
  - DFA on input α terminates in state s
    - α处理完毕后处于状态s
- Next: **reduce** by X → β if[归约]
  - s contains item X → β·
- Or, **shift** if[移进]
  - s contains item X → β·*t*ω
  - Equivalent to saying s has a transition labeled *t*