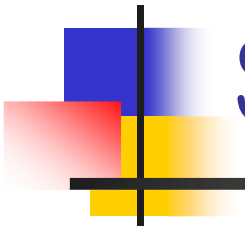
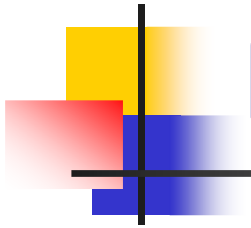


Scheme Implementation

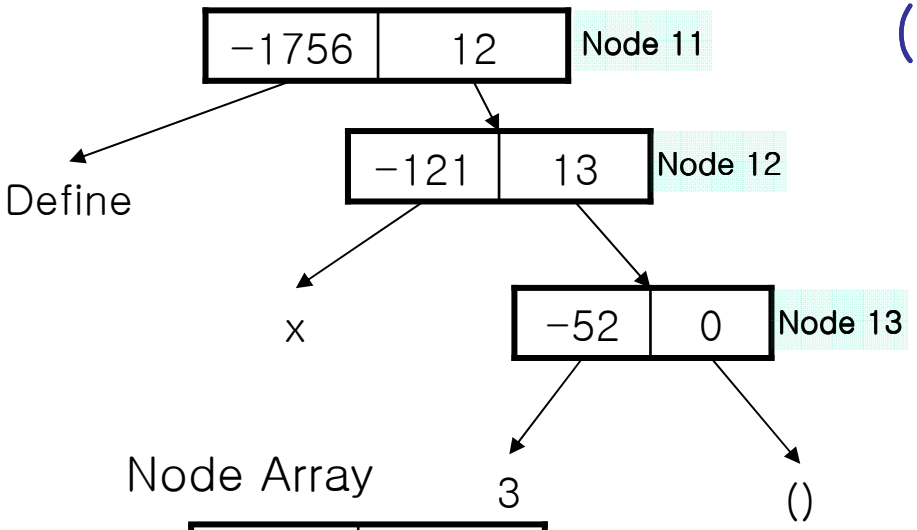


Parse Tree & Node Array

- Build the parse tree with the node array

  when a command input comes
  - Read the input token by token
  - Make an new node and attach it to the tree
  - When we make a new node, allot it from the array
- each node stores the indices of its left child and right child

Parse Tree & Node Array Example (1)



(define x 3)

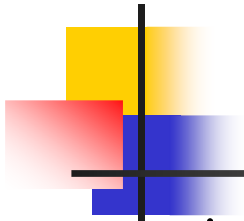
Node Array

Array Index	Left	Right
...		
11	−1756	12
12	−121	13
13	−52	0

Symbol Hash Table

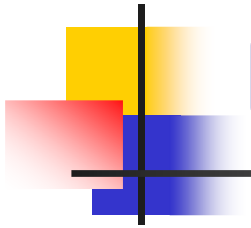
Hash Value	Symbol	Link of Value
...		
−52	3	NULL
...		
−121	x	NULL
...		
−1756	define	NULL
...		

Parse Tree & Node Array Example (2)

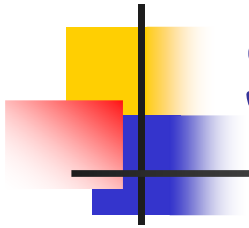


- Input: (define x 3)
  - Read the token '(' and allot the new root node (node 11) from the array.
  - Read the token ‘define’. Store the hash table index (= -1756) of 'define' as the left child index of node 11 and the node id (= 12) of the newly allotted node as the right child index of node 11.

Parse Tree & Node Array Example (3)



- Read the token 'x' and store the hash table index (= -121) of ‘x’ as the left child index of node 12. Then allot the new node and store the id (= 13) of it as the right child index of node 12.
- Read the next token ‘3’ and store the hash table index (= -52) of ‘3’ as the left child index of node 13. Since next token is ')', store null index (= 0) as the right child index of node 13 without allotting a new node. .



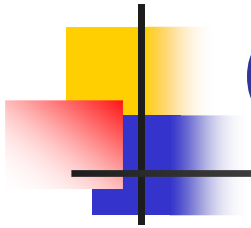
Symbol Table

- In Scheme, Symbol Table stores all “meaningful words”.
  - Built-in words, numbers, function names, symbols, etc.
  - Hash table should hold words and links for their contents.
- For fast search and retrieve, we’ll use hash table as a symbol table.
  - Use negative numbers for hash entries as its indices.
  - In the other hand, use positive numbers for entries of the node array

Symbol Table Example

Hash Value	Symbol	Link of Value
-1	“+”	NULL
-2	“car”	NULL
…		
-52	“3”	NULL
…		
-121	“x”	-52
…		
-3285	“list”	20
…		
-3501	“func”	25

- Assume we have a hash function “f” from each symbol to hash value.
- We assign some “special” region for “built-in words”.
  - f(“+”) = -1
- Hash function example
  - f(“3”) = -52, “3” is a number.
  - f(“x”) = -121, “x” is a variable.
  - f(“list”) = -3285, “list” is a list. List have a link for list data.
  - f(“func”) = -3501, “func” is a function. Function also have a link for function contents.



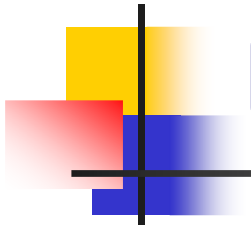
Collision Resolution (1)

- Two different words can have same hash value.
  - Hash table can store one element for one hash value. So, “collision problem” may happen.
- Here, we use Open Addressing Policy for hash table.
  - Resolve collision problem by using the first empty element from hash value.
  - If f(“3”)=-231 and f(“list”)=-231, the latter entry uses -232 as hash value.

Collision Resolution (2)

- Open Addressing has some weak points.
  - May make clusters, so search will be inefficient.
  - Very difficult to delete clustered entry.
- Here, We assume no delete operation and we have enough memory, so just use Open Addressing Policy.

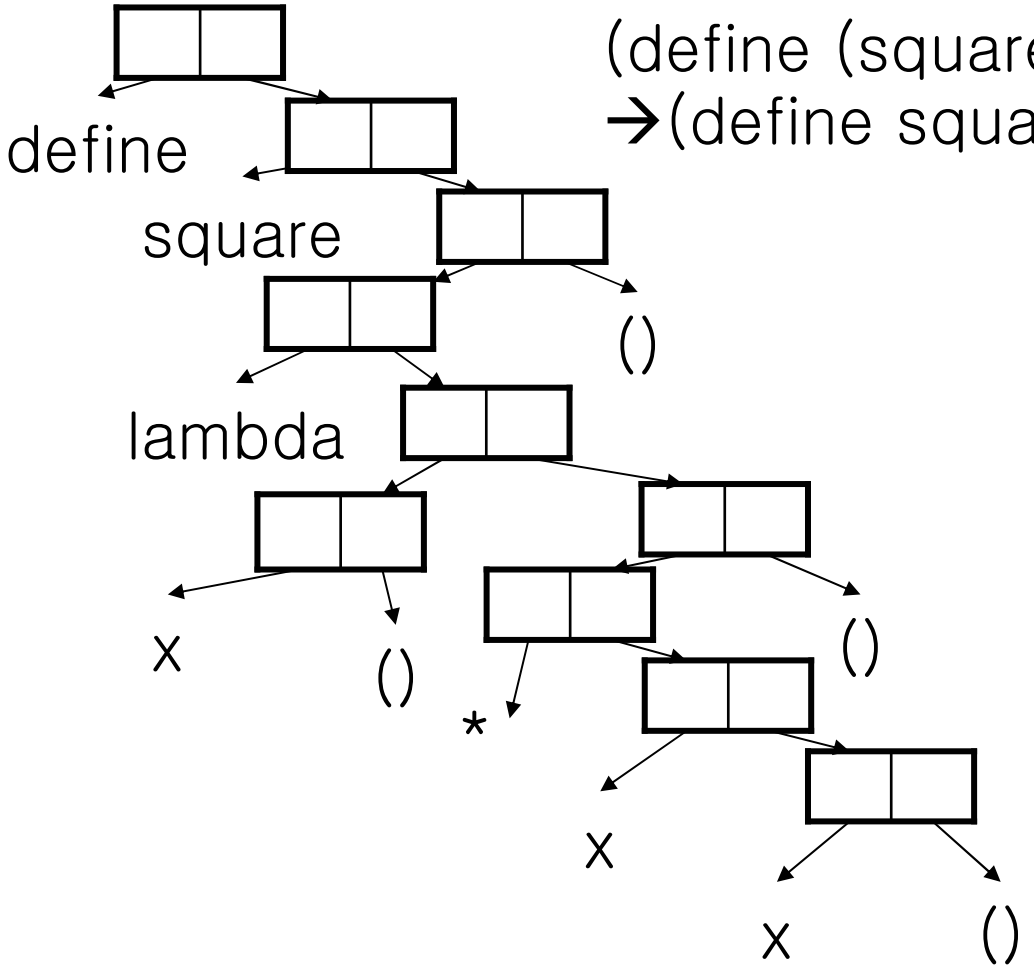
Hash Value	Symbol	Link of Value
…	…	…
-231	“3”	NULL
-232	“list”	53
…	…	…



Example

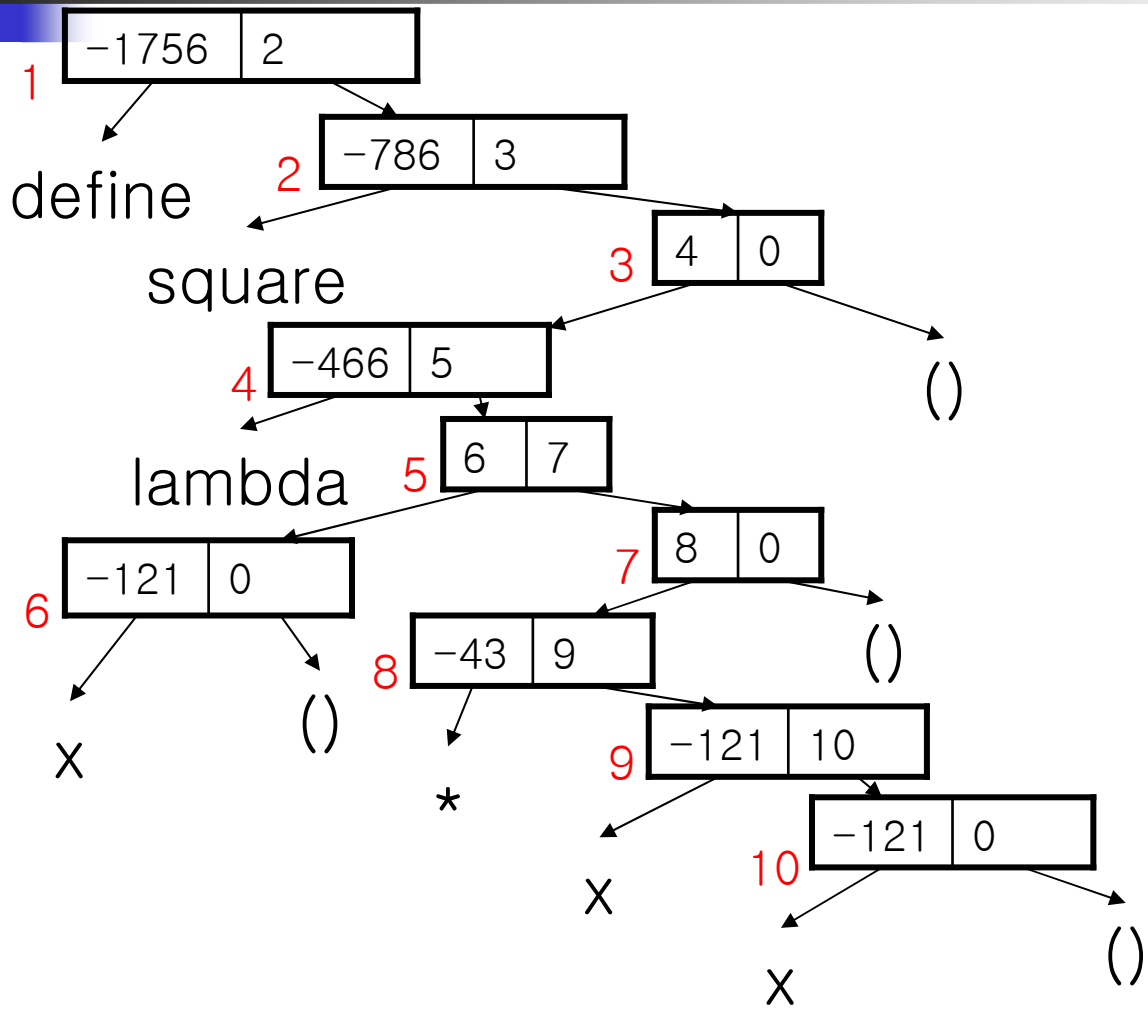
- Read & evaluate the following commands
  - (define (square x) (* x x))
  - (define x 3)
  - (square 6)

Convert non lambda form to lambda form



(define (square x) (* x x))
→(define square (lambda (x) (* x x)))

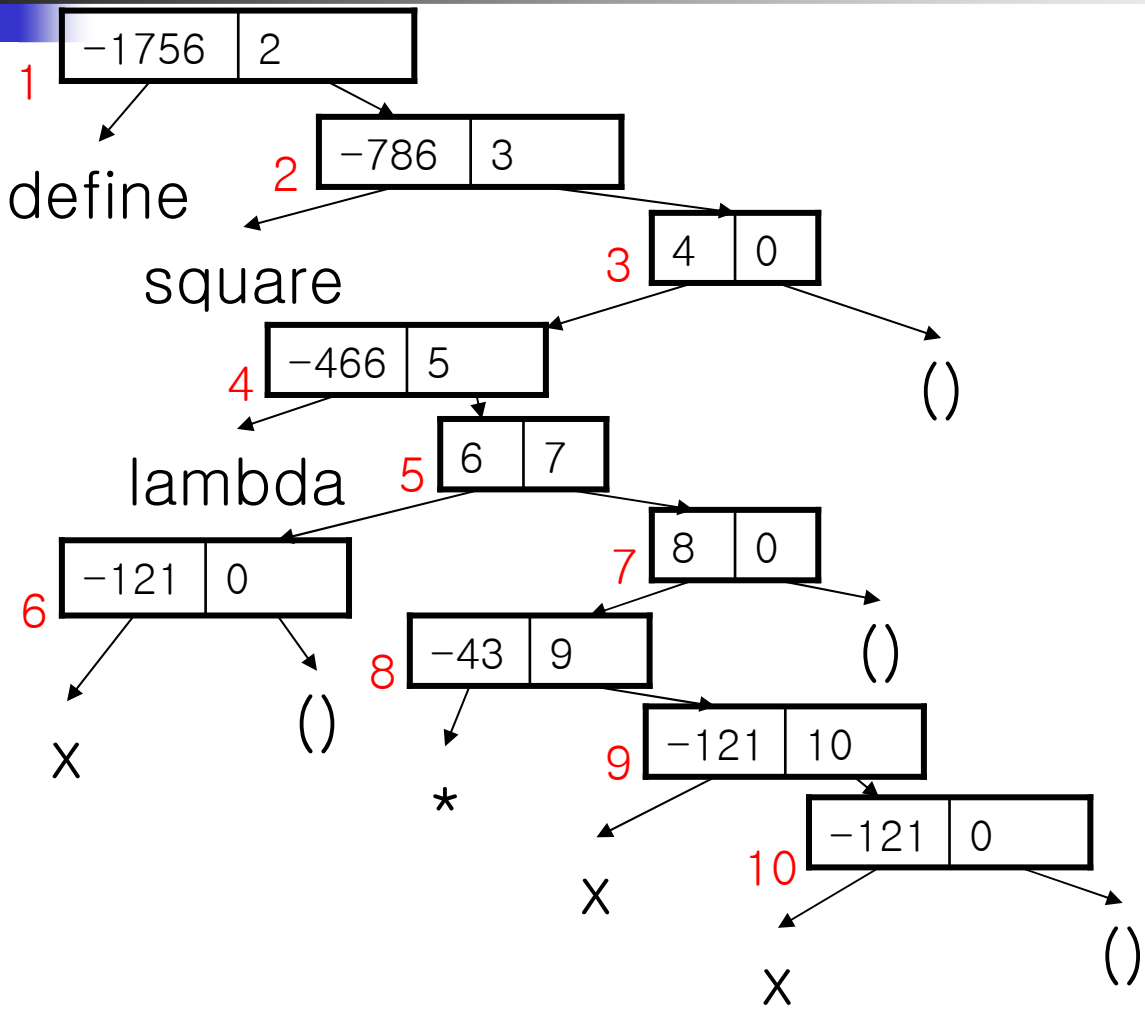
Parse Tree of (define square (lambda (x) (* x x)))



Node Array

Node ID	Left	Right
1	-1756	2
2	-786	3
3	4	0
4	-466	5
5	6	7
6	-121	0
7	8	0
8	-43	9
9	-121	10
10	-121	0

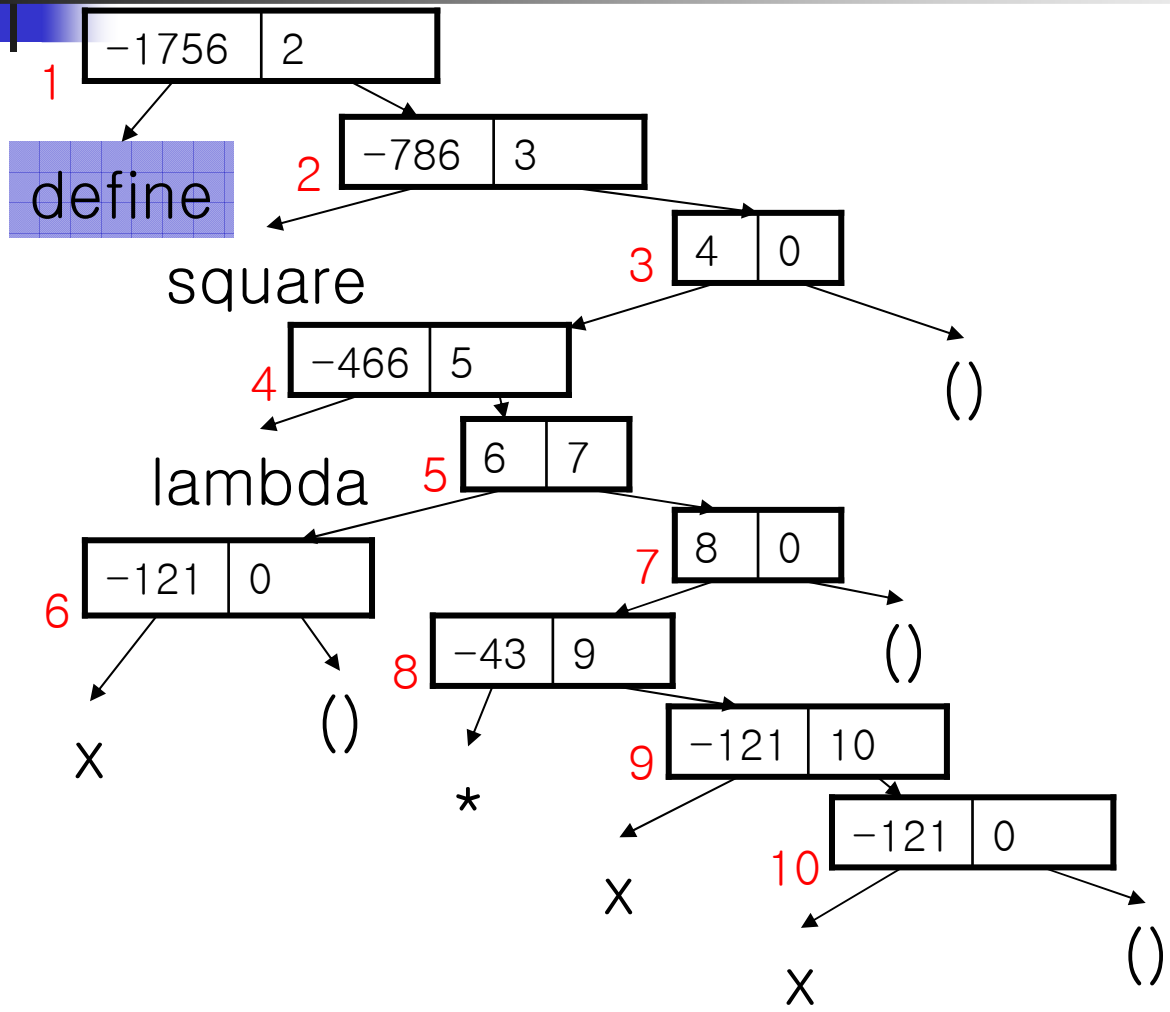
Parse Tree of (define square (lambda (x) (* x x)))



Hash Table

Hash Value	Symbol	Link of Value
...		
-43	*	
...		
-121	X	
...		
-466	Lambda	
...		
-786	square	
...		
-1756	Define	
...		

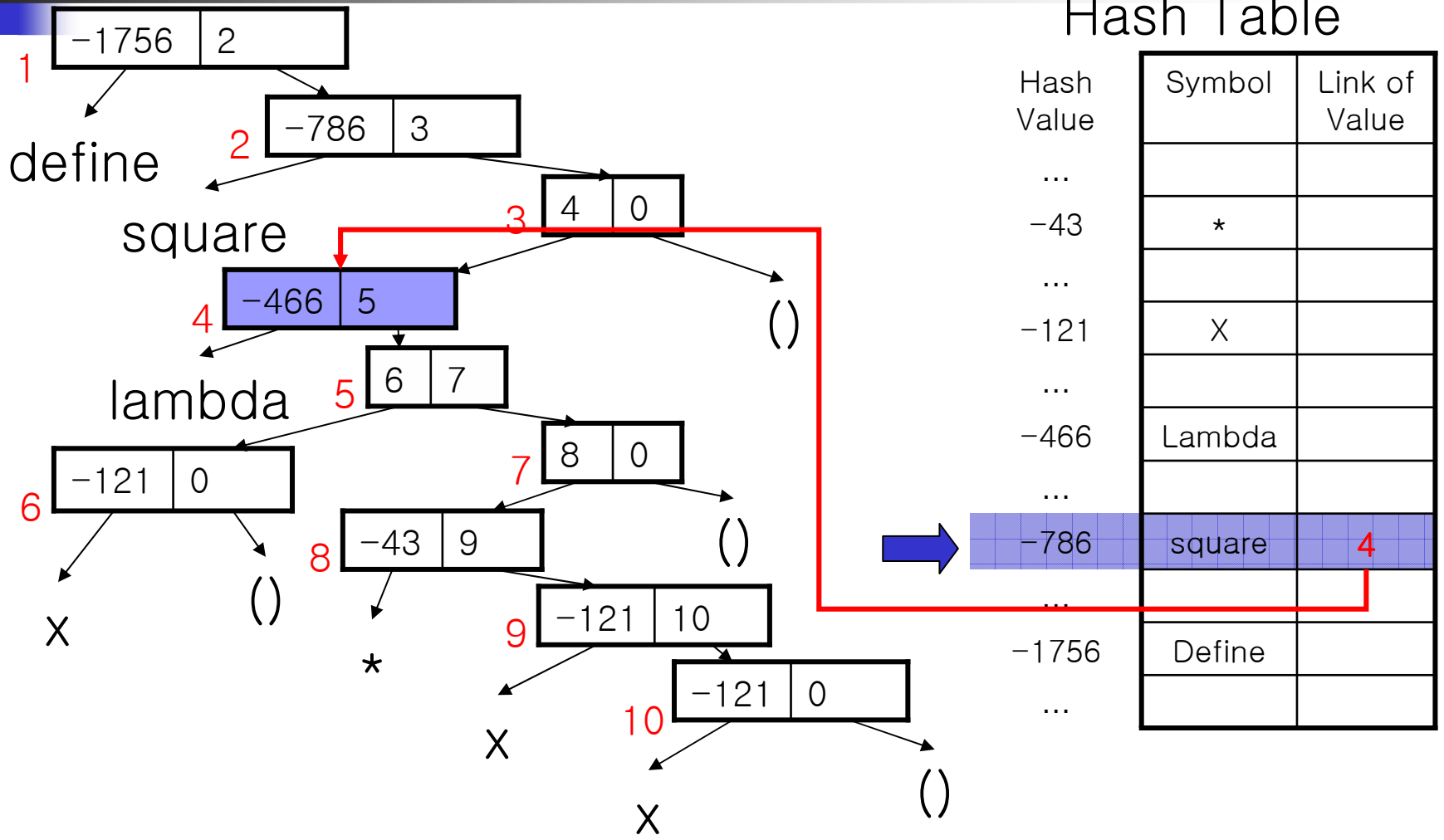
Evaluation of (define square (lambda (x) (* x x)))



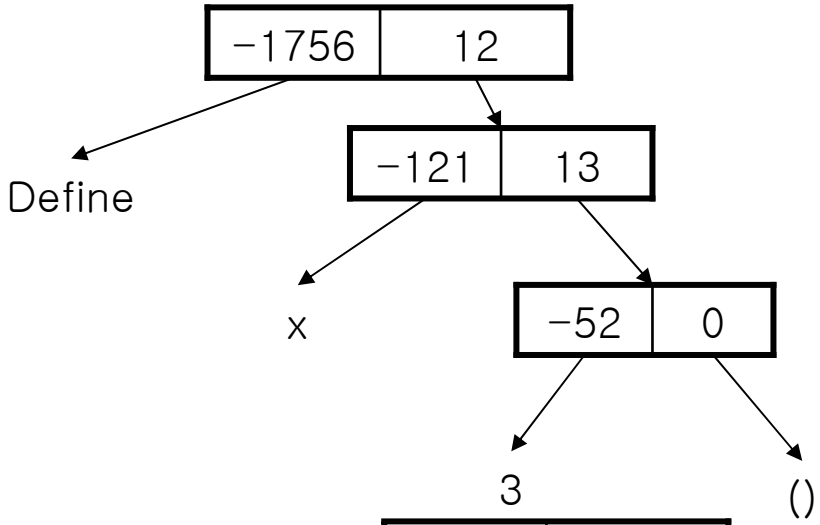
Hash Table

Hash Value	Symbol	Link of Value
...		
-43	*	
...		
-121	X	
...		
-466	Lambda	
...		
-786	square	
...		
-1756	Define	
...		

Evaluation of (define square (lambda (x) (* x x)))



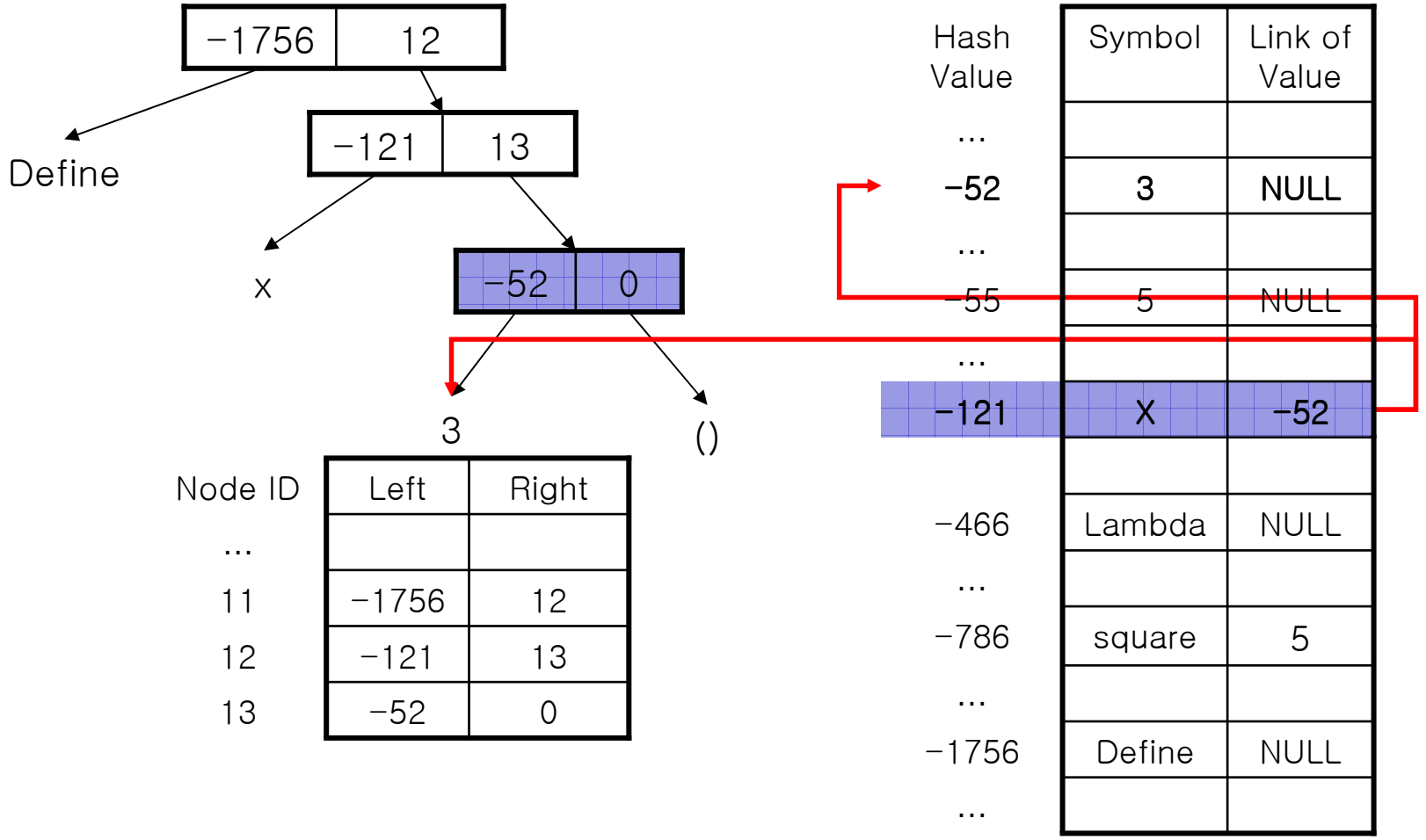
Parse Tree of (define x 3)



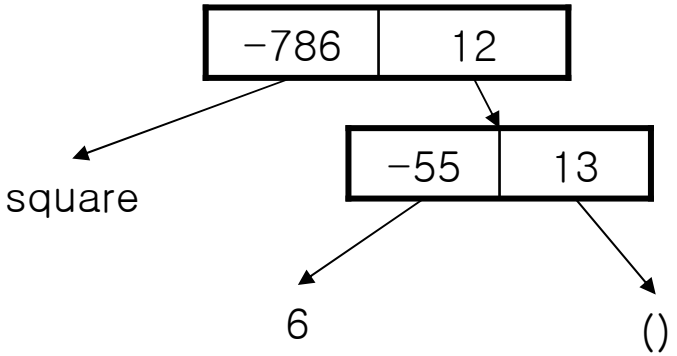
Node ID	Left	Right
...		
11	-1756	12
12	-121	13
13	-52	0

Hash Value	Symbol	Link of Value
...		
-43	*	NULL
...		
-52	3	NULL
...		
-121	X	NULL
..		
-466	Lambda	NULL
...		
-786	square	5
...		
-1756	Define	NULL
...		

Evaluation of (define x 3)



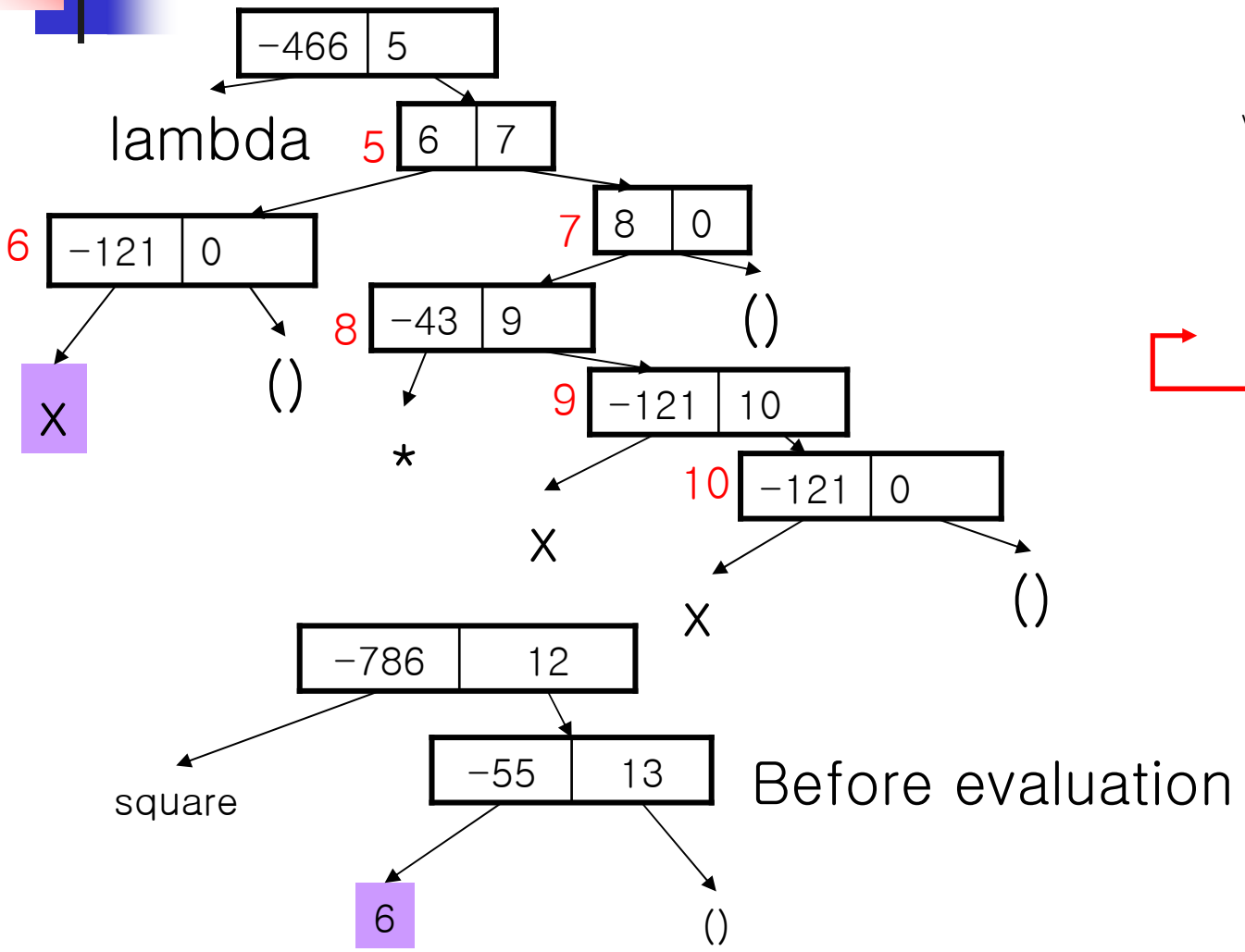
Parse Tree of (square 6)



Node ID	Left	Right
...		
14	-786	12
15	-55	13

Hash Value	Symbol	Link of Value
...		
-52	3	NULL
...		
-55	6	NULL
...		
-121	X	-52
...		
-466	Lambda	NULL
...		
-786	square	5
...		
-1756	Define	NULL
...		

Evaluation of (square 6)



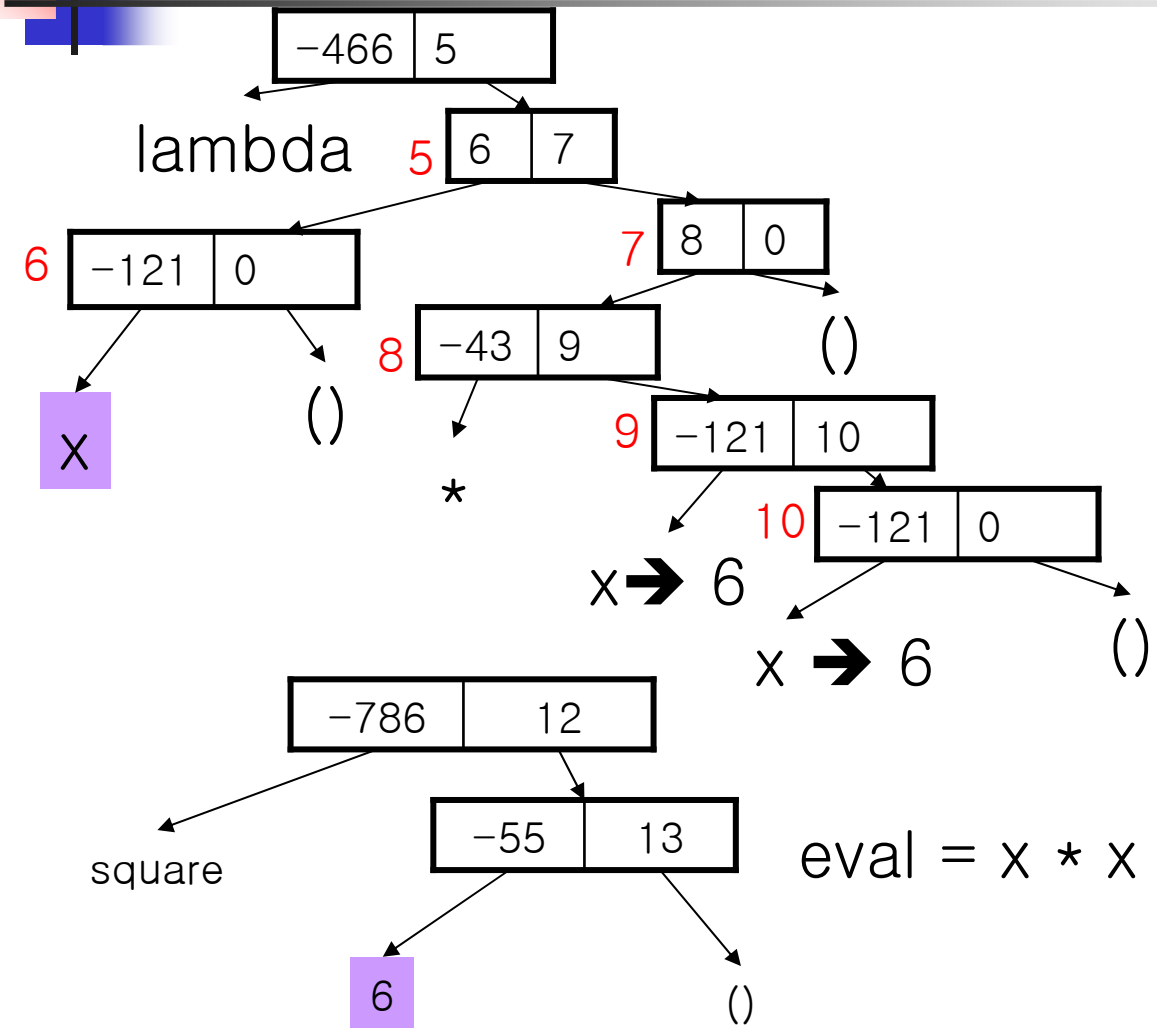
Before evaluation

Hash Value	Symbol	Link of Value
...		
-52	3	NULL
...		
-55	6	NULL
...		
-121	X	-55
...		
-786	square	5
...		

Stack

-52

Evaluation of (square 6)



Hash Value	Symbol	Link of Value
...		
−52	3	NULL
...		
−55	6	NULL
...		
−121	X	−55
...		
−786	square	5
...		

Stack

−52

eval = x * x = 6 * 6 = 36

Evaluation of (square 6)