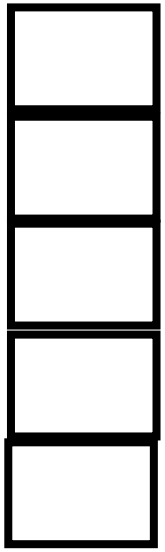
Procedures with Parameters and Local Variables

```
int x;
int y;
void aa(int i, int z) int a; int b1; {
        a = i+z;
        b1 = i * z;
        print i;
        print z;
        print i+z;
        print a;
        print b1;
        print x;
        print y;
        x = b1;
}
x = 10;
y = 20;
aa(x,y);
print x;
```

Runtime Stack

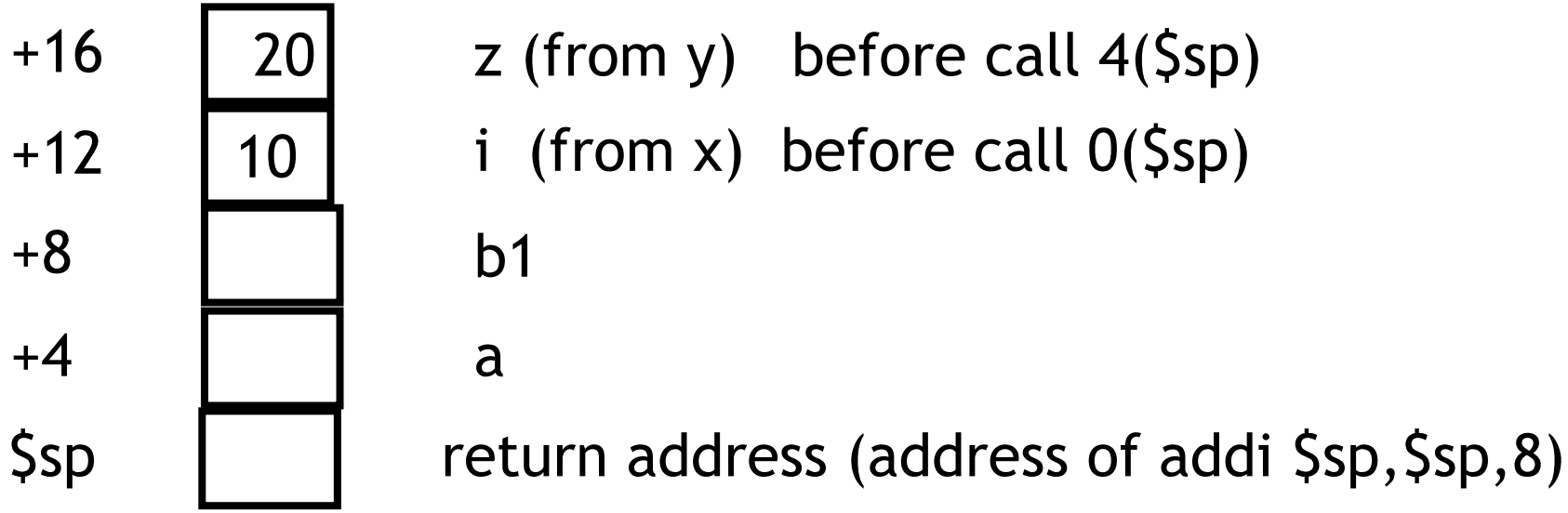


+16	z (from y)
+12	i (from x)
+8	b1
+4	a
$sp	return address (address of addi $sp,$sp,8)

Procedures with Parameters and Local Variables

```
lw      $t0, x          aa(x, y);
lw      $t1, y
subu    $sp, $sp, 8     space for parameters
sw      $t0, 0($sp)     put parameters on the stack
sw      $t1, 4($sp)
jal     aa              call the procedure
addi$sp, $sp, 8         pop parameters
```

Runtime Stack



Procedures with Parameters and Local Variables

```
aa:
        subu    $sp, 12         Space for locals and return address
        sw      $ra, ($sp)
        lw      $t0, 12($sp)    a = i+z;
        lw      $t1, 16($sp)
        add     $t2, $t0, $t1
        sw      $t2, 4($sp)
        lw      $t0, 12($sp)    b1 = i*z;
        lw      $t1, 16($sp)
        mul $t2, $t0, $t1
        sw      $t2, 8($sp)
        lw      $t0, 12($sp)    print i;
        li      $v0, 1
        move    $a0, $t0
        syscall
        li      $v0, 4
        la      $a0, _nl
        syscall
```

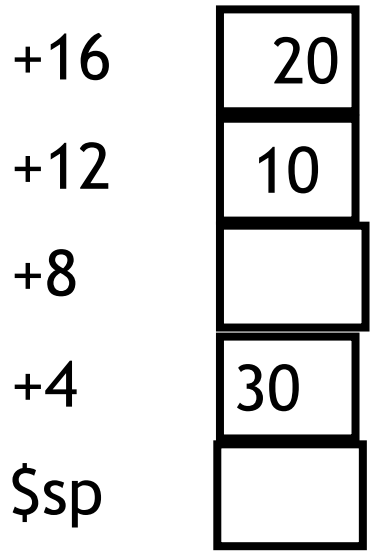
Procedures with Parameters and Local Variables

```
lw      $t0, 12($sp)      print i+z;
lw      $t1, 16($sp)
add     $t2, $t0, $t1
li      $v0, 1
move    $a0, $t2
syscall
li      $v0, 4
la      $a0, _nl
syscall
lw      $t0, 4($sp)       print a;
li      $v0, 1
move    $a0, $t0
syscall
li      $v0, 4
la      $a0, _nl
syscall
```

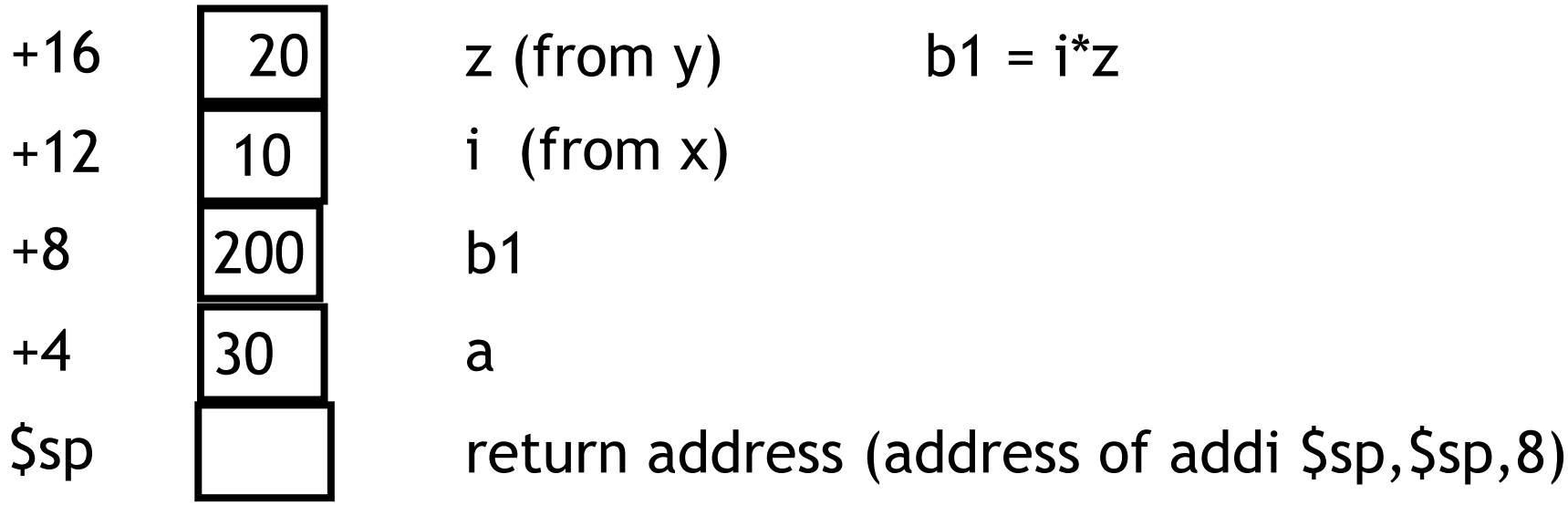
Procedures with Parameters and Local Variables

```
lw      $t0, y          print y;
li      $v0, 1
move    $a0, $t0
syscall
li      $v0, 4
la      $a0, _nl
syscall
lw      $t0, 8($sp)     x = b1;
sw      $t0, x
lw      $ra, ($sp)
addi    $sp, 12         pop local variables and return address
jr      $ra
```

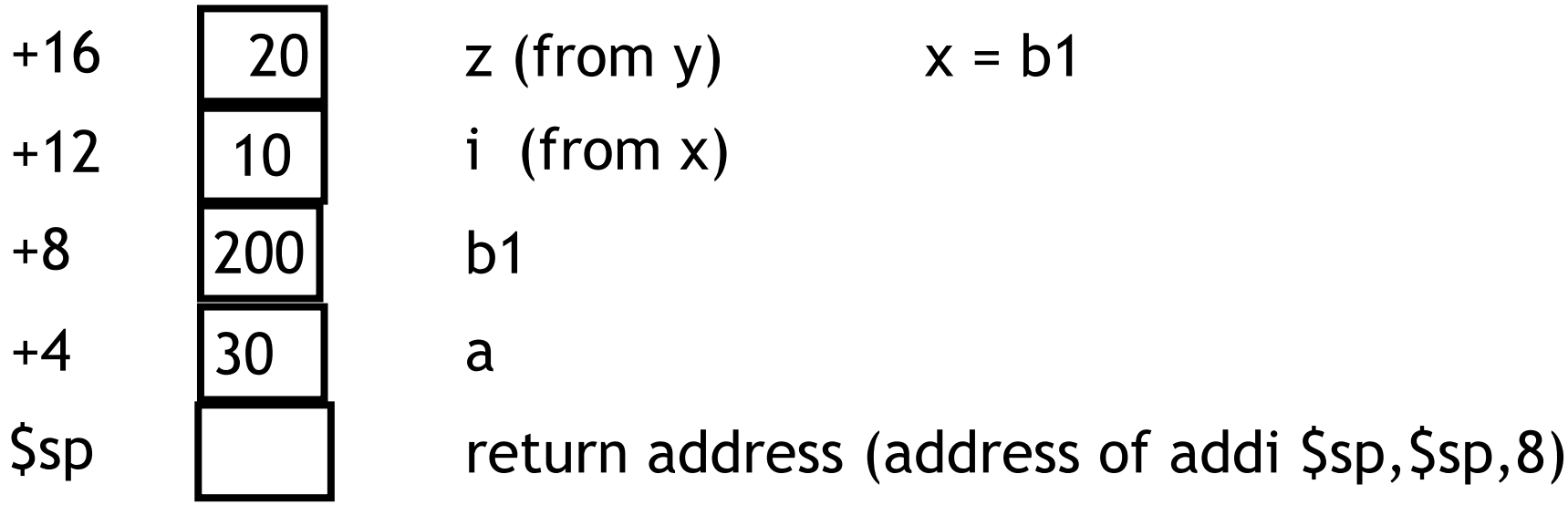
Runtime Stack



Runtime Stack



Runtime Stack



Procedures with Parameters and Local Variables

- Where to make changes from yacc4?
  - IdList
    - Formal parameters and local variables
  - ExprResList
    - Actual parameters
  - ProcSymTab
  - SymTab Attributes
  - doRval
  - doAssign
  - Any other place you use id

Actions in Productions

```
%}
%union {
    int num;
    char * string;
}

%type <string> Parens;

%%
Prog        :   Parens';'
                        {printf("%s", $1);}
Parens      :   '('{$<num>$ =++ depth;} Parens')'{--depth;}Parens
                        {
                            temp = (char *) malloc(8+strlen($3)+strlen($6)+1);
                            sprintf(temp, "(%d%s)%s",$<num>2,$3,$6);
                            $$ = temp;
                        } ;
Parens      :           { $$ = "";} ;

%%
```